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VOL. 7. DECEMBER, 1921. NO. 29.

JOURNAL

OF

THE INSTITUTION

OF

PETROLEUM TECHNOLOGISTS

AND

RECORD OF TRANSACTIONS.

FOUNDED 1913—INCORPORATED 1914.

PUBLISHED BY
THE INSTITUTION OF PETROLEUM TECHNOLOGISTS,
8, John Street, Adelphi, Strand, London, W.C. 2.
AND PRINTED BY
William Brendon & Son, Limited,
Mayflower Press, Plymouth.

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Issue of Journal. The Journal appears in four parts per sessional volume, viz. in January, April, July and October. A brochure describing the origin, progress and purposes of the Institution, and comprising also the Memorandum and Articles of Association, the By-Laws and Regulations of the Institution, the Library Catalogue to date (with subject index), and the List of Members, was published in September, 1915, to be followed periodically by revisions of the Library Catalogue and List of Members. The List of Members brought up to March, 1921, is now issued.

Members of all classes are entitled to receive these publications free: for additional copies of the Journal they will be charged at the price of seven shillings and sixpence per part, and of the brochures at the prices stated on the wrappers, varying in proportion to bulk.

Changes of Address. It is particularly requested that members notify the Secretary immediately of any change of address; and members are also requested to advise the Parcel Post Department as well as the Letter Office, of any temporary change of address, as, unless this is done, parcel post packets will not be re-addressed; but will be returned to the offices of the Institution in London, thus incurring further expense for postage.

To Authors of Papers. Papers should be written in the third person, and the copy should be carefully corrected by the author before it is presented.

All drawings, diagrams or other illustrations should be sent in a fit state for direct photographic reproduction.

All quotations, technical terms, and localisms should be indicated by means of inverted commas.

Foreign weights, measures, and costs should be given whenever possible, and also their English equivalents.

It is suggested that authors append as complete a bibliography of the subject treated as may be possible.

All papers and notes submitted to the Institution are supposed to be original communications unless distinctly stated to be otherwise, in which case the exact reference to the previous publication should be given.

Communications upon papers read at meetings, notices of personal movements, or other matter for which publication is desired in the next issue of the Journal, should be in the hands of the Editor on or before the last day of December, March, June or September as the case may be. Subsequent delivery may be too late for insertion.

The Council desire to draw the attention of authors to the serious increase in the cost of production. Papers, both for the Journal and for communication to the Institution, should be as concise and condensed as possible.

Communications. The Council invite members to submit papers for the forthcoming session. Communications to the Institution will, subject to the approval of the Publication Committee, be published in the Journal.

Appointments Register. A Register will be kept at the Offices of the Institution for the convenience of firms requiring the services of members and for members requiring appointments, but on the distinct understanding that the Institution accepts no responsibility and gives no guarantee.

Library. The Institution's Library at No. 5 John Street, Adelphi, may be consulted between 11 and 4 daily. Extensive additions are being made to the current and standard literature on Petroleum.

Additions since publication of last Journal.

From Department of Interior, U.S. Geological Survey :—

Report. Manganese and Manganiferous Ores in 1919. By H. A. C. Jenison.

Report. Quicksilver in 1919. By F. L. Ransome.

Report. Gold, Silver, Copper, Lead, and Zinc in California and Oregon in 1919. By Charles G. Yale.

Report. Gold, Silver, Copper, and Lead in Alaska in 1919. By Alfred H. Brooks and George C. Martin.

Report. Talc and Soapstone in 1919. By J. S. Driller.

Report. Zinc in 1918. By C. E. Siebenthal.

Report. Coke in 1918. By C. E. Lesher and F. G. Tyron.

Water Supply, Paper No. 447. Surface Water-Supply of the Pacific Slope of Southern California. By H. D. McGlashan.

Water Supply, Paper No. 449. Ground Water in the Meriden Area, Connecticut. By Gerald A. Waring.

Water Supply, Paper No. 462. Surface Water-Supply of the United States, 1917. Part XII. North Pacific Slope Drainage Basins. By Nathan C. Grover, G. L. Parker, and W. A. Lamb.

Water Supply, Paper No. 466. Ground Water in the Southington-Granby Area, Connecticut. By Harold S. Palmer.

Bulletin No. 715 M. Permian Salt Deposits of the South-Central United States. By N. H. Darton.

Bulletin No. 719. Preliminary Report on Petroleum in Alaska. By George C. Martin.

Professional, Paper No. 121. Helium-Bearing Natural Gas. By G. Sherburne Rogers.

From Department of Interior, Bureau of Mines :—

Report of Committee on Standardization of Petroleum Specifications.

Bulletin No. 191. Quality of Gasoline Marketed in the United States. By H. H. Hill and E. W. Dean.

Bulletin No. 195. Underground Conditions in Oil Fields. By A. W. Ambrose.

Bulletin No. 206. Petroleum Laws of all America. By J. W. Thompson.

From the Imperial Mineral Resources Bureau :—

The Mineral Industry of the British Empire and Foreign Countries. War Period. Phosphates. 1913–19.

From the Geological Survey of Great Britain and the Museum of Practical Geology :—

Summary of Progress for 1920.

From United States Internal Revenue, Treasury Department :—

Manual of the Oil and Gas Industry under the American Revenue Act of 1918. By R. Arnold and J. L. Darnell.

Purchased :—

Catalogue of British Scientific and Technical Books, 1921. British Science Guild.

The attention of members is drawn to the new supplement of the Journal which deals with current Petroleum literature. To make this section of the maximum usefulness it is necessary that there should be full co-operation between chemists, engineers and geologists, and that matter which has inadvertently escaped notice shall be immediately sent in to the Editor. The Institution has been indebted to Mr. Andrew Campbell for the compilation of the bibliography during this past session, and is now under similar obligation to Mr. W. J. Wilson.

Advertisements in the Journal. A limited number of Advertisements of firms interested in the Petroleum Industry may be inserted in the Journal. Application for terms, etc., should be made to Messrs. Commercial Publicity Service, Ltd., 58 Warwick Street, Regent Street, London, W. 1.

LIST OF ADVERTISERS.

(Members are desired, when making enquiries or placing orders with advertisers, to mention that they have seen their announcement in the Journal.)

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PERSONAL NOTES OF MEMBERS AND SPECIAL NOTICES.

It is suggested that Members of the Institution send information regarding their movements to the Secretary for insertion under this heading.

WE much regret that in the List of Members recently published, our Honorary Member, Mr. JOHN COURTENAY CLARKE, was inadvertently

described as Mr. James C. Clark. This will be rectified in the next List of Members.

Mr. HUGH PEARSON has kindly presented to the Library of the Institution thirty-five volumes of the Transactions of the Institution of Mining Engineers.

Mr. C. E. KEEP has left for Burma to take up an appointment as geologist with Messrs. The Indo-Burma Petroleum Company.

Major T. DALBY HACKETT has recently returned home from Burma.

Professor Sir JOHN CADMAN, K.C.M.G., sailed for the United States in November.

Lieut.-Col. Sir A. T. WILSON has left for Mohammerah, Persian Gulf.

Mr. WILLIAM SUTTON is leaving for the United States early in December.

Mr. JAMES BROWN has informed the Secretary that he has changed his name to James Chapman Brown, and that he is sailing for Borneo on December 9th.

Dr. W. R. ORMANDY wishes to announce change of address from Oakley House, Bloomsbury Street, to 18 Belsize Grove, Belsize Park, N.W. 3.

ARRANGEMENTS have been made for the Fourth Annual Dinner of the Institution to be held at the Connaught Rooms, Kingsway, on Tuesday, March 21st, 1922, and Mr. Ashley Carter has again kindly consented to act as Honorary Secretary to the Dinner Committee.

THE Chancellor and Trustees of the University of Pittsburg announce the appointment of Mr. Edward Ray Weidlein as Director of the Mellon Institute of Industrial Research.

Messrs. CADBURY BROTHERS, Ltd., have forwarded us an interesting and well-illustrated brochure detailing the steps taken, during the recent coal stoppage, for the conversion of their boiler plant from coal to oil firing. Eight 30′ by 8′ Lancashire boilers were changed over to fuel oil, and operations were only suspended for four days. The oil was taken to Bournville by railway tank-cars.

THE Mining Society of the University of Birmingham, of which Professor Sir John Cadman, K.C.M.G., is President, has just issued its

first annual publication of technical papers, and a summary is given of Sir John Cadman's recent Presidential Address to the Society on "Petroleum and its Importance to the British Empire." An account of the work carried out by the recently inaugurated Mining Research Department, of which Dr. J. S. Haldane is Honorary Professor and Director of Research, is promised in future issues.

SPECIFICATIONS.

We have received the List of British Standard Specifications and Reports from the British Engineering Standards Association, including a number of matters of interest to the petroleum profession. Copies may be had from 28 Victoria Street, Westminster, London, S.W.1.

COMMITTEE ON STANDARDIZATION AND NOMENCLATURE.

The Council of the Institution has appointed a Standing Committee to deal with the standardization of tests relating to mineral oils and the nomenclature of naphthology. The Committee is to possess wide powers of co-option and will undoubtedly ask for the assistance and co-operation of those members of the Institution who have special acquaintance with the multifarious tests and estimations now current. Sub-committees will be appointed to deal with groups of tests, and an attempt will be made to put forward an authoritative series of methods of analysis. The urgent need for such work is felt in other countries, and the excellent work already carried out in the United States needs no mention here. On another page of this issue of the Journal it will be noticed that further efforts are being initiated in America.

Members will be kept in touch with the Committee's activities by means of periodical reports in the Journal.

PETROLEUM NOTES AND CORRESPONDENCE.

It has been decided to open columns in the Journal to be devoted to general petroleum notes and to correspondence. Members of the Institution are invited to contribute thereto as occasion warrants.

CRYSTAL PALACE LECTURES ON PETROLEUM.

The Council have arranged to publish in book form a complete series of the Crystal Palace Lectures, which will be rewritten and illustrated with some ninety-two diagrams and plates. The work is to be issued as a Popular Petroleum Book for the general petroleum-reading world, with glossary, statistical tables (including various weights and measures for technical reference), a bibliography and other useful information. The Council are anxious that the members should support this venture, and those members desiring to subscribe to the volume can obtain further information on application to the Secretary.

At the moment of writing, the book is in the Press and should be available early in the New Year.

List of Contributors.

Introductory	Sir FREDERICK BLACK.
Romance of Petroleum	The late Sir BOVERTON REDWOOD, Bart.
Wild Catting	E. H. CUNNINGHAM CRAIG.
Prospecting	G. HOWELL.
Drilling	H. MAY.
Transport and Storage	H. BARRINGER.
Refining	A. E. DUNSTAN.
Chemistry of Petroleum	F. B. THOLE.
Utilization of Light Oil	W. ORMANDY.
,, Heavy Oil	J. S. S. BRAME.
Nomenclature	J. KEWLEY.
Statistics, etc.	ARTHUR W. EASTLAKE.

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PATRON: HIS MAJESTY THE KING.

Universities Committee Letter to Graduate Members of the Universities of Great Britain and Ireland.

MANY men distinguished in letters and science are suffering great privation in Austria to-day, and the present condition of student life is a matter of grave concern for the future welfare of Europe. It is the problem presented by this serious situation that called into

activity the Universities Committee, at the instigation of Lord Robert Cecil. This Committee has appealed to the Universities of Great Britain and Ireland to come to the assistance of the Professors and Undergraduates in the war-stricken areas of Europe. The British Universities are responding generously; the sum of £1 per head per student is being gradually raised, giving to date a total of £32,000; this has been done mainly by student effort. The money is being spent in a carefully organized plan for the relief of the most destitute students in the Universities of Austria, Hungary, Poland, Czecho-Slovakia, etc., and in giving a certain amount of food and clothing to the Professors and Lecturers of the Austrian Universities.

The Universities Committee, whose appeal to students on behalf of students has received such an encouraging response, is asking an equal effort on the part of men of learning in Great Britain and Ireland in the work of relieving the distressed Senior Members of sister Universities. Men who are famous throughout the civilized world—Exner, Tchermak, von Lang, Palisa, Strygowski, Wilhelm, Klein, Fuchs, Fried, Ebner, Charlemont, Lorenz-Liburnau, and many others—are finding very great difficulty in carrying on their work. If every man and woman who has had the privilege of studying in this country would give £1 1s., the staffs of the Austrian Universities would be at least sure of adequate nourishment for themselves and their families.

(*Signed*) WILLIAM BRAGG.
BRYCE.
A. S. EDDINGTON.
RICHARD A. GREGORY.
HALDANE OF CLOAN.
FREDERIC G. KENYON.
WALTER LOCK.
DONALD MACALISTER.
CHARLES J. MARTIN.
HENRY A. MIERS.
GILBERT MURRAY.
E. RUTHERFORD.
M. E. SADLER.
ARTHUR SCHUSTER.
NAPIER SHAW.
A. E. SHIPLEY.
GEORGE ADAM SMITH.
ERNEST H. STARLING.
J. J. THOMSON.

Since the above signatures to this appeal were given, facts as to the conditions obtaining among the men of science and learning in Russia have been brought to our attention. Between 1914 *and* 1920, 30,000 *doctors died through war and pestilence. The need for doctors, scientific men, engineers, agriculturists, etc., is vital to the country. Through seven*

years of war and revolution, with almost complete severance from Western Europe, Russia has been reduced to a position dangerous to civilization. Famine of an intensity unparalleled in human record has devastated the country. The American Relief Administration and other funds are bending all their energies on trying to save the children. The Universities Committee, in co-operation with the British Committee for Aiding Men of Letters and Science in Russia, hope also, with your assistance, to relieve some of the most acute distress in the Universities of Russia.

CHEQUES should be made payable to the Hon. Treasurer, Universities Committee, and sent to the Organizing Secretary, at Fishmongers' Hall, London Bridge, E.C.4.

November, 1921. ELEONORA IREDALE, *Organising Secretary.*

AMERICAN SOCIETY FOR TESTING MATERIALS.

At the Twenty-Fourth Annual Meeting of the American Society for Testing Materials, held at Asbury Park, N.J., June 21–24, 1921, the Report of Committee D-2 (on Petroleum Products and Lubricants) was presented by the Secretary, and the following actions were taken on the Committee's recommendations :—

The proposed revision of the Test for Free Acid in the Standard Tests for Lubricants was referred to letter ballot of the Society for adoption as a standard.

The present Standard Cloud and Pour Test and Cold Test were withdrawn from the Standard Tests for Lubricants, and the revised Tentative Methods of Test for Cloud and Pour Points of Petroleum Products were accepted as a tentative standard.

The Tentative Method of Test for Distillation of Gasolene, Naphtha, Kerosene and Similar Petroleum Products, in revised form, was accepted as a tentative standard, and attention was called to the fact that the Society had acted upon the recommendation of Committee D-1 (on Preservative Coatings) to withdraw the present Distillation Test for Paint Thinners, provided that the Tentative Method of Test for Distillation was accepted.

The Tests for the Melting Point of Paraffin Wax ; Open Cup Flash and Fire Test ; and for Flash-Point by Means of the Pensky-Martens

Closed Tester were accepted, in revised form, as tentative standards, and the Tests for Viscosity of Fuel Oils and Other Oils of Similar Viscosity; for Sulphur in Naphthas and Illuminating Oils; for Water in Petroleum Products; and for Water and Sediment in Petroleum Products by Means of Centrifuge, were accepted without revision as tentative standards.

The proposed Tentative Method of Test for Saponification Number was accepted, and the question of the title of this method was discussed.

The following revised methods for the Tentative Method of Test for Detection of Free Sulphur and Corrosive Sulphur Compounds in Petroleum Products were submitted and accepted :—

"1. This method of test is applicable for the detection of free sulphur and corrosive sulphur compounds in oil.

"2. (*a*) A clean strip of mechanically polished pure sheet copper about $\frac{1}{2}$-in. wide and 3 in. long shall be put into a sample of the oil contained in a clean test tube, about half the length of the copper strip being submerged. The test tube shall then be closed with a stopper (venting where volatile materials are being tested) and left to stand over night at a temperature of 150° F.

"(*b*) At the end of this time the copper strip shall be removed and washed free from oil with gasoline. It shall then be compared with a similar strip of copper freshly polished in a similar manner.

"3. If free sulphur or corrosive sulphur compounds are present in the oil the copper test strip will appear discoloured when compared with the freshly cleaned copper."

Attention was called to the Committee's favourable action upon the revised Standard Method of Test for Flash-Point of Volatile Flammable Liquids.

The reports of Sub-Committees I (on Petrolatum), IV (on Grease), and VI (on Colour), were briefly presented, and the following papers were then read by their authors, and discussed :—

"The Refining of Petroleum," by C. K. Francis.

"Improvements in Apparatus for Testing Petroleum Products," by T. G. Delbridge.

"Problems Involved in the Development of Specifications for Motor Gasoline," by E. W. Dean.

PAPERS WHICH HAVE BEEN READ BEFORE THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

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E. H. Cunningham Craig	The Prospective Oil-fields of Western Canada	3
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Prof. V. B. Lewes	The Chemistry of the "Cracking" of Heavy Oils	3
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Members requiring the Journal bound should communicate with our printers, Messrs. Wm. Brendon & Son, Ltd., Plymouth, who will undertake the work according to requirements at most reasonable prices.

The Fifty-eighth General Meeting was held at the house of the Royal Society of Arts, John Street, Adelphi, W.C., on Tuesday, October 11th, 1921, Professor J. S. S. Brame, the President, occupying the Chair.

The Members of Council present were Sir F. W. Black, Mr. H. Barringer, Mr. E. H. Cunningham Craig, Mr. Arthur W. Eastlake, Dr. W. R. Ormandy, Mr. T. C. Palmer, and Professor J. S. S. Brame in the Chair.

The President, in opening the meeting, said that on the present occasion, the first meeting of the Session 1921–22, he wished to refer to the excellent series of papers which had been promised to the Institution for the first three meetings. That evening Dr. Hume was going to speak about the Egyptian Oil-fields; at the next meeting, in November, Mr. Beeby Thompson would give a paper on "The Elimination of Oil-field Losses," and for the December meeting the Engineer-in-Chief of the Navy, Engineer Vice-Admiral Sir George Goodwin, had promised to read a paper on the "Use of Oil Fuel in the Navy." The Institution was extremely fortunate in having Dr. Hume present that evening, because he was all too frequently abroad. When, however, Dr. Hume knew that he was coming home to England for a time he very kindly said that he would address the Institution on the subject of the Egyptian Oil-fields if a convenient date could be arranged, and the first meeting of the Session fortunately afforded an opportunity.

Before asking Dr. Hume to deliver his address, he would request the Acting-Secretary and Librarian, Commander R. E. Stokes-Rees, who had been appointed by the Council during the summer recess, to read the list of new members, the ballot papers having been sent in for consideration that day.

As *Members*:—Aby Bourne Corner Bolton, Rear-Admiral Philip Wylie Dumas, R.N., Walter Sidney Fellows, William Ewart Gladstone Hudson-Holden, Cuthbert Baring Horwood, Harry Leslie Little, George Francis McKillop, William Fulton Murray, Robert Joseph Stringer, John Edward Treacy, Edwin Kerby Wallen, John Henry Walton, John Ancell Wright, Alexander Matthew Wylie.

As *Associate Members*:—Gerardus Jan Jacobus Both, Felippe Fliess, Clarence Percival Hale, Marcel Edouard de Jarny, Len Riley Roberts, Enrique Romero Robles, James Edward John Taylor, William Gambell Weeks, Leonard Langdale Wrathall.

As *Students*:—Thomas Donald Ambrose, Geoffrey Chambers Flower, Harry Temple Watts.

As *Associates*:—Paul Nicolai Koggerman, H. H. Boyd Stewart.

There were also elected on the 30th May the following gentlemen:—

As *Members*:—Henry Robert James Conacher, Elliott Alfred Evans (transference from Associate Member), John Waterloo van Geuns, Raymond Gilbert, Arthur Charles Hearn, Peter Kerr, Gordon Pitt (transference from Associate Member), John Venn Stevens, Arthur Wade, D.Sc., Frank Ainsworth Willcox, Lieut.-Col. Sir Arnold Talbot Witson.

As *Associate Members*:—James Henderson Abercrombie, Frederic Horace Garner, Archibald Victor Monk, William Wallace Watt.

As *Student*:—John Morley Bailey.

As *Associates*:—Victor Dvorkovitz, William John Thomas Ivey, Sydney Herbert North, Samuel Charles Rogers, John Thomas Taylor.

Before commencing to read his paper, **Dr. Hume** said that he had been introduced to the Institution by the late Sir Boverton Redwood, and it was always Sir Boverton's hope that a meeting would some day be arranged to discuss the subject of the Egyptian oil-fields. He felt he had not the field so entirely to himself on the present occasion as he would wish to. There were many members present who knew Egypt well, and he was afraid he would have a rather more critical audience than was generally the case.

The Geology of the Egyptian Oil-field.

By W. F. Hume, D.Sc., A.R.C.S., etc.

General History of the Egyptian Oil-fields.

The presence of petroleum in Egypt was known from very early times, its occurrence on the surface of pools at Gebel Zeit being recognized by the Romans, who named the locality *Mons Petrolius*. This now famous spot is situated at about 163 miles south-east of Suez on the western shore of the Gulf of Suez, and at the foot of a range some 1400 feet in height, which is a conspicuous landmark for all steamers up or down the Red Sea. When the Société Soufrière began the exploitation of sulphur on the peninsula of Gemsa in 1865, about twelve miles south of Gebel Zeit, tunnels were made into the gypsum containing it close to the seashore. Considerable interest was aroused when petroleum was found to be floating on the sea-water which had collected in these excavations.

The history of the study of the economic resources of Egypt is divisible into periods of marked activity often alternating with others of stagnation. The interest of the Egyptian Government in these

oil occurrences began in 1884, when M. de Bay called attention to the presence of petroleum in the old workings at Gemsa and at Gebel Zeit. It was arranged that he should undertake borings at these localities, and from a report by Colonel Ardagh it is evident that very fair supplies were obtained at Gemsa. The first boring reached a supply of oil at 106 feet, yielding 25 barrels a day, while a second well reached 137 feet, yielding 500 cubic metres a day of mixed oil and water. One third was oil. Nevertheless, £100,000 having been spent in this venture, the Government did not proceed further with it.

In 1886 an expedition was organized under Mr. L. H. Mitchell, who studied the former oil distribution on a wider scale, he being subsequently joined by Colonel Stewart, the British Consul-General at Odessa, who was invited to Egypt for this purpose. Their results were embodied in two reports (L. H. Mitchell, "Ras Gemsah and Gebel Zeit, Cairo, 1887," and Colonel Stewart, "Report on the Petroleum Districts of Red Sea Coast, Cairo, 1888"), which contained very valuable data as to the distribution of petroliferous deposits in Egypt.

In 1896 a new period of activity commenced with the formation of the Geological Survey under Captain (now Colonel) H. G. Lyons, D.Sc., F.R.S. In this year began the systematic geological examination of Egyptian territory, which has continued with increasing precision and detail up to the present day. This study was the foundation of the existent phosphate and manganese industries, but the visits to Gemsa and Zeit led to pessimistic conceptions of the oil-field possibilities. The present writer, coming direct from a brief inspection of the great developments at Baku, was unfavourably impressed by the thin and limited films on the pools of Zeitia, as well as by their close proximity to the granitic range. He did not himself examine the Jemsa area.

New impetus was given to prospecting for oil in Egypt when the Department of Mines was founded in 1906 under Mr. John Wells. Gemsa in particular was opened up, and in April, 1908, the first flowing well came in. The writer's interest was early enlisted in this expansion, the late Mr. Douglas Home, appointed Government Inspector at Gemsa, reporting to him and sending samples of the strata passed through during the operations of the companies which were formed in rapid succession after the initial success at Jemsa. The failure of these efforts led to stagnation so far as companies were concerned, but the researches of the Government to obtain further light continued with unabated vigour. Among other activities a detailed topographical map was prepared of the oil-field area by Dr. Ball and his colleagues.

The opening up of the famous Hurghada oil-field again induced

private enterprise, which, though checked by the war, has now been resumed with the greatest energy. The part played by the Egyptian Government in the new movement has been indicated on the geological side by the publication of a series of Petroleum Research Bulletins, while in its general aspects it has been fully summarized by Mr. E. M. Dowson, C.B.E., Under-Secretary of State for Finance, in his "Note on the Programme and Policy of the Government with regard to the Investigation and Development of the Petroleum Resources of Egypt."

Geological Formations Represented in the Egyptian Oil-field Region.

This area is defined in a very wide sense as the one in which research for oil indications has been most largely developed; it includes the peninsula of Sinai and the shores of the gulf of Suez and Red Sea, in so far as they are embraced within Egyptian territory.

The main strata given are represented in the following stratigraphical table:—

	Recent and Pleistocene	Recent and newer raised coral reefs, Red Sea limestones with species of *Laganum*, *Clypeaster*, etc.
	Plio-Pleistocene (precise dating uncertain)	Marine gravels with *Pecten Vasseli*, limestones with *Pecten Fischeri*, *P. Vasseli*, etc., oolite beds.
	Plio-Miocene or possibly Upper Miocene	*Ostrea gingensis* and *Tellina lacunosa* beds.
Miocene (very variable, but in places certainly over 1000 metres)	Upper Middle Miocene (Helvetian or Vindobonian)	Highly fossiliferous strata with varied Miocene *Pecten* fauna (*P. Josslingi*, *P. Kochi*, *P. sub-Malvinæ*), etc.
	Lower Middle Miocene (Schlier)	Beds of shallow-water origin above. Clays and gypsum with dolomitic limestone in places.
	Lower Miocene (Burdigalian)	How far the lower strata of the Miocene are referable to this division is still uncertain.

The large amount of lateral variation makes the correlation of the Miocene strata very difficult.

Eocene (about 700 metres or 2000 feet)	Upper Eocene (non-Nummulitic in the main)	Gypseous clays, conglomerates, phosphate beds (especially developed in the Tanka and Hammam Faraün districts).
	Middle and Lower Eocene (Nummulitic Formations)	Very thick in Northern Sinai, but thinning southward. Almost entirely massive limestones forming the summits of important ranges (Raha, Hammam Faraün, etc.).

Upper Cretaceous Fossiliferous beds nearly 500 metres thick, where developed the sandy facies another 500 metres. Total about 1000 metres, or 3000 feet	*a*. Maestrichtian	The late M. Fourtau suggested that all beds of white chalk above those with definite *Gryphæa vesicularis* should be referred here. These contain sponges (*Ventriculites*), marcasite concretions, etc.
	b. Campanian	This includes the typical *Gryphæa vesicularis* beds in the north with *Ostrea Villei* and the main phosphate beds to the south.
	c. Santonian *a*, *b*, and *c* are probably equivalent to the Upper Chalk in England	This is a very typical series resembling the strata of the type locality of Abu Roash, near Cairo, in North Sinai, while further south it is characterized by *Ostrea Boucheroni*, *Plicaltya Ferryi*, etc.
	Turonian (Middle Chalk)	In North Sinai Hippuritic limestones are developed as at Abu Roash, with *Nerinæa Requieniana* and *Trochactæon Salomonis*. South of lat. 28° N. this is largely replaced by a sandy facies. In part of the region ammonite beds are an important member near the junction with the underlying formation.
	Cenomanian (Lower Chalk)	This formation is one of the most characteristic in all Egypt, merging into the sandy formation commonly known as "Nubian Sandstone." south of lat. 27°50′ N. To the north these beds contain characteristic sea-urchins (species of *Hemiaster* (*H. cubicus*, etc.) and Oysters (*Ostrea flabellata*, *O. olisiponensis*, *O. mermeti*, etc.).

All the above are Upper Cretaceous in age.

Lower Cretaceous, 1500–2000 feet	Albian (Gault)	In the Maghara Range of North Sinai are beds with single corals referable to this age Further south these are probably sandy, and merged into the great formation of the Nubian sandstone.
	Aptian (Lower Greensand in part)	An important fossiliferous series containing a large variety of ammonites (species of *Pusozia*, *Phylloceras*, etc.). *Terebratula sella*, species of *Trigonia*, etc.
	Barremian	M. Douvillé believes strata of this age to be represented at the base of the Lower Cretaceous series represented.

Jurassic, 2000 feet upwards	Upper Jurassic or Lusitanian	Well seen in Gebel-um-Mafruth, etc., Maghara Range, North Sinai. Is equivalent to the Glandarian Kalk of Syria.
	Oxfordian	Best shown at Gebel Touriat, Maghara Range, where the beds have abundant *Collyrites bicordata* and *Terebratula Lamberti*.
	Callovian	Best shown in Wadi Maghara strata, rich in species of *Pygurus* and *Rhynchonella Orbignyi*.
	Bathonian	Soft shales, brownish marls and limestones with characteristic ammonites (*Cœloceras Humphriesi*, etc.). Best shown in Wadi Maghara.
	Bajocian	Alternating grey limestones and reddish sandstones with species of *Rhynchonella* and *Terebratula*. Best developed in Shusht-el-Maghara and Gebel Hemaiyir.
	?Lias or Trias	Unfossiliferous sandstones underlying the above Jurassic in Shusht-el-Maghara, the summit of the Maghara Range.
Carboniferous, 320 metres or about 1000 feet	Upper Carboniferous	Sandstones with some clay and shale bands. Contains Lepidodendron.
	Lower Carboniferous	Limestones with *Orthis Michelini*, *Athyris Royssi*, *Spirifer striatus*, etc., thus identical with the Lower Carboniferous of Western Europe. Sandstones with some shales with worm-tracks and other markings.
	Permian, Silurian, Ordovician, Cambrian	No strata of any of these ages have been identified in Egypt or Sinai by fossiliferous evidence.
	Pre-Cambrian	A great series of *Igneous Rock*, (Granites, Diorites, etc., are intrusive into Ancient Sedimentaries) both of volcanic and more purely sedimentary character forming a vast Schist succession. These apparently overlie *Gneisses*, specially developed in the Cataract region.

Detailed Account of Search for Petroleum in Egypt.

The de Bay wells drilled at Gemsa in 1886 had produced evidence which led to further examination by the Egyptian Petroleum Co., Ltd., and a favourable report by Messrs. D. A. Sutherland and the late D. A. Louis. Definite boring operations were decided upon and began on January 1, 1908. It is of interest to note that the progress of the work was from the very outset under Government supervision. Owing to certain changes having taken place in Government departments during this period, Colonel Lyons, Director-General of the Survey Department, appointed the late Mr. Douglas Home as Inspector of the Geological Survey, his duties being to report all details regarding the progress of the work to myself, and to collect samples of the strata passed through for retention at the Geological Museum. The chief driller in this field was Mr. John Josh, of Petrolia, Canada. No. 1 well made good progress through dark limestone with subsidiary clays, and was drilled in successfully to an oil rich in benzine on April 1st, 1909. Other wells followed in fairly rapid succession, the first four being all oil producers, but of the twenty-one wells drilled, only seven actually yielded petroleum, and of these only three were of first-class character. Though the oil itself was of valuable quality the supply fell off somewhat rapidly, and at the present time only one well occasionally has a small and very temporary production. The first geological results obtained were of a puzzling character. While the first well was entirely in limestone, those following showed alternations of gypsum and limestone in varying proportions. The oil-yielding zone was found to be a narrow belt bordering the sea; to the westward of it the limestone diminished, the gypsum increasing in importance, while finally salt in great masses became the essential feature in a boring made to test the main anticline near Gemsa Bay.

Speaking broadly, the petroleum was apparently present in porous calcareous members of a thick gypsum limestone series, the age of which has now been definitely determined as not earlier than the Lower Miocene. Immediately an underlying sandstone was encountered (presumably the Nubian sandstone formation) the presence of oil was replaced by that of water.

The years 1908 to 1913, inclusive, were marked by an effort to determine the oil-producing possibilities of a number of small anticlines present on the main coast of Egypt, near Gemsa, and on the adjoining islands. Mr. John Wells commenced operations almost simultaneously at Ras Bahar (February 23, 1910), Gaysum Island (March and April, 1910), and Jubal Island (June, 1910), these being

conducted on behalf of the African Prospecting Syndicate and Eastern Petroleum Company respectively. At the same time (June 27, 1910), the Egyptian Oil Trust began boring on Um el Haimet Island, situated eastward of Gemsa, and separated from it by a relatively shallow sea channel.

The results, if instructive from the point of underground structure, were most disappointing as regards oil possibilities. At Ras Bahar the deeper No. 1 bore traversed nearly 3000 feet of alternating gypsum, shale and salt; on Gaysum the same salt-containing series began at 450 feet below surface, the salt (sometimes in continuous masses over two hundred feet in thickness) alternating with shales and gypsum to the depth attained—2668 feet. In Jubal Island the results were different, where the earlier borings began in gypsum, then passed through dolomitic limestones which contained petroleum in small quantity. No large supplies had been met with before red granite was entered. Five other borings undertaken on this island showed increasing thicknesses of shale and gypsum away from the centre of the dome.

The Um el Haimet borings equally indicated the presence of salt zones, their alternation with gypsum and clay, and in addition the presence of granitic sands of varying thickness distributed between 1280 and 1710 feet below surface.

Drilling in 1911 and 1912 revealed the presence of the gypsum, clay, and salt series at Ranim Island, near the south end of Gebel Zeit, and also at the extreme northern end of that range, north-west of Ras Dib, near where the valley Wadi Dara enters the sea. As none of these salt-containing bores have shown any satisfactory indications of petroleum it remains doubtful at present whether such anticlines as those above-mentioned would yield results if the deeper strata were penetrated. Another series of borings begun in 1910 were in the meanwhile presenting records of a different character, these being sunk at various localities at the southern end of the Gebel Zeit peninsula.

The first was located near the surface seepage and was carried to a depth of 610 feet, when it was abandoned on meeting the igneous rocks. Two others were begun on a small anticline north of Zeitia Harbour in April, 1911, and closed down in March, 1912. In these borings limestone played an important part, and some thin bands were saturated with petroleum, but these were not of sufficient thickness to be producers.

A fourth was begun in June, 1912, and small thicknesses of salt were encountered. The work was abandoned at 1322 feet, when granite was recorded as having been entered. So far the borings had

thrown but little light on the deeper-seated structure, but one sunk on the western side of the Zeit range, early in 1913, went through a more normal succession, such as was indicated at the surface. Beneath a considerable thickness of gypsum and clay followed a fairly thick limestone which contained a certain amount of petroleum. Drilling was continued to 1193 feet, when the Nubian sandstone was entered, a strong supply of water being then encountered. The effort was then discontinued. This boring, it should be stated, was well down the western limb of the anticline.

Up to this date the efforts to develop the minor anticlines had failed both on the Egyptian mainland and on the islands, the only oil obtained being along a line at Gemsa which did not display striking anticlinal characters. In none of the localities tried were there any surface indications.

In 1886 Mr. L. H. Mitchell had stated that a tract of country further to the south, between Gebel Ahu Shaar and Ahu Mingar, though presenting no indications of petroleum, was, nevertheless, geologically similar to the country further north which he regarded as favourable for oil production.

In 1898 the late Mr. Barron noted oil rock at the foot of the Red Sea hills west of Desht-el-Dubha, a domal area twelve miles south of Hurghada, but did not come down to the coast. Had he done so there is little doubt that this acute observer would have been impressed with the interesting domal structures of Hurghada and Abu Mingar.

In 1907 licences for these areas and certain adjoining ones (Jifatin Island, for example) were taken by the Cairo Syndicate, the map on which the application was based being signed by Mr. Earle Trevor, who at that time was carrying out active prospecting work for minerals in Northern Sinai.

In 1909 the Geological Survey of Egypt commenced a detailed topographical and geological survey of the oil-fields region, this embracing the area extending from the Red Sea Hills to the Gulf of Suez, and including the Zeit Hills, Gemsa, and the islands already mentioned. It fell to my own lot to push southward to the Hurghada anticline, and in March, 1911, my interest was greatly aroused by the discovery of an oil-smelling limestone in the western anticline of Hurghada. From this time onward the Egyptian Government paid special attention to the Hurghada area. The Anglo-Egyptian Oil-fields, Ltd., had also been attracted to the region, and in May, 1912, Mr. Blyth of the E.O.T. and myself paid a joint visit to Hurghada, Desht el Kora, and the two Jifatin islands. On this occasion we examined the Hurghada oil-rock occurrence together. When Professor Mrazec came

from Roumania to examine the oil-field region with me, a Government party, including ourselves, Mr. Dabell of the Department of Mines, and Mr. Murray, again visited the spot, and the latter prepared a 1 : 10,000 map of the Abu Mingar and Hurghada areas.

I have dwelt at some length on the Government operations in this interesting area because the data available for its history were re-studied by Mr. Greaves, Controller of the Department of Mines, his colleagues, Messrs. Coxon and Rogers, and myself, from the archives in our possession. It has not been possible to deal so fully with the Companies' operations, as these are largely unpublished, but the direct activities of the Anglo-Egyptian Oil-fields, Ltd., undoubtedly date from the presentation to them of a detailed report by Dr. Wanner, in which boring near the oil-rock exposure was recommended.

The success of this enterprise is now a matter of history, a series of gushers being obtained from late in 1913 to the present day. As this paper is being written in England the detailed data of production are not to my hand, but most of those who are interested in this question have followed the figures as issued in papers dealing with petroleum, and are aware that this field has frequently yielded supplies approaching 5000 tons a week.

Up till 1912 the geology of the oil-field region had remained wrapped in a considerable amount of obscurity. New data were, however, obtained in that year, which threw a flood of light on many points hitherto obscure. During my expedition of that year a young Arab chainman found a number of sea-urchins in a limestone underlying the great gypsum-clay series in Wadi Kabrit, at the northern end of the Zeit range, and further up the valley we obtained a rich fauna in the same formation, containing such typical Miocene fossils as *Aturia aturi* and *Terebratula Miocenica*. These the late M. Fourtau identified as belonging to a period transitional between the lower and middle Miocene, and in this connection it may be recalled that the late Professor Suess regarded *Aturia aturi* as the type fossil of the Schlier shallow-water formation which forms the lower section of the middle Miocene in Austria. This settled any controversy as to the age of the gypsum bordering the Red Sea.

The members of the Geological Survey (Barron and Hume) on first studying the relations of the gypsum in Gebel Zeit regarded it as the probable altered equivalents of the Cretaceous and Eocene strata which occupied a similar position in the Esh Mellaha range further to the west.

Since the Government Petroleum Research began, the *Aturia aturi* beds have been shown to have a wide extension, having been obtained

by Professor Madgwick as far north as Shallufa, between Suez and Ismailia.

Globigerina Marls.—When examining the oil-field area about 1905-6, Dr. Erb and Mr. J. Wells found that a series of marls underlying the gypsum in Gebel Zeit, and in places over one hundred feet in thickness, were filled with the minute tests of the foraminifer *Globigerina*. Mr. C. G. Sara, kindly instructed by Mr. Wells, first introduced me to this interesting formation, which was subsequently proved to extend throughout the Gebel Zeit range. The Petroleum Research studies in 1918 indicated the Miocene succession to be as follows :—

Upper gypsum beds.

Intergypseous clays and limestones.

Lower gypsum beds.

Globigerina marls.

Lower Miocene limestones, with flint conglomerates at the base.

The Gemsa oil was undoubtedly obtained from porous limestones belonging to the above series, and it is to this source that we look for any benzine-rich light oils that may yet be found in Egypt.

The most important advance in our knowledge of the distribution of oil in Egypt was indicated when Mr. Vernon, geologist of the Anglo-Egyptian Oil-fields, Ltd., was permitted to disclose some of the results of his investigations at Hurghada to the writer, in return for information supplied regarding the surface structure at Gebel Zeit. On comparing notes it was found that all the representative members of the Zeit series were represented in the underground succession at Hurghada, including such characteristic members as the globigerina marls and the flint conglomerate. Beneath the conglomerate was a succession of fine sands and carbonaceous shales similar to beds well known in Upper Egypt as members of the upper Cretaceous formation. The lighter oils were found associated with calcareous strata in the Miocene gypsum-limestone series, the heavier oils being, on the other hand, present in the fine-grained Cretaceous strata.

Distribution of Petroleum in the Sinai Peninsula.

This interesting conclusion has brought the oil geology of Egypt proper into relation with that of the Sinai Peninsula. As early as 1868 Bauerman (*Quart. Journ. Geol. Soc.*, Vol. XXV, 1869) had drawn attention to the bituminous sandstones of Wadi Gharandel, on the western coast of Sinai north of the range of Gebel Hammam Faraûn. In

January, 1888, Colonel Stewart, when at Tor, the quarantine port of Sinai, learnt that petroleum was frequently found floating at low tide on the sea at Abu Durba, twenty-five miles north-westward of that town. Oil seepages were also noted on the shore near Gebel Tanka, north of Abu Zenima, this leading to boring operations in August, 1910. The deepest of these reached a depth of 2930 feet. Commencing in beds of Eocene age it traversed the whole of the fossiliferous Cretaceous strata, finally entering the Nubian sandstone. An oil-yielding layer was struck between three and four hundred feet from the surface, but as the supply was only three barrels a week the enterprise was eventually abandoned.

The Petroleum Research study of the Egyptian Government was extended to the Sinai peninsula in 1917–18, detailed examinations being made of the Abu Durba and Tanka areas. It was evident that petroleum had been present in both the Eocene, Cretaceous, and Nubian sandstone formations, oil rock being found at several horizons. The most consistent development is in the Cenomanian strata immediately above their junction with the Nubian sandstone. On the other hand, where the fossiliferous Cenomanian strata are not present, having passed into the sandstone type, the first limestone or marly strata above the sandstone show evidence of the former presence of oil, or it may be present in the underlying sandstone.

Thus indications of the former presence of petroleum have been noted in almost every member of the Cretaceous and Eocene succession. (See diagram, based on Plate I of *Petroleum Research Bulletin, No.* 2, "Occurrences of Petroleum in Western Sinai.") Messrs. Moon and Sadek have found repeated indications of its wide distribution in the Cenomanian strata of North Sinai; at Abu Durba, where the lowest fossiliferous limestone is Turonian, the sandstone immediately below is highly bituminous, and has been proved still to contain thick liquid petroleum at only a few feet below the surface; at Abu Zenima the oil-impregnated strata are at a higher Cretaceous horizon, the Santonian, while in the Tanka area Eocene beds have both yielded petroleum in borings and have also been highly impregnated with oil near the surface.

The Cenomanian strata of Sinai are the lowest in the geological scale to contain indications of petroleum. The Jurassic strata in the northern hills of Sinai are in lithological structure most favourably developed to act as oil repositories, yet careful search by the writer's colleagues above mentioned have not yielded the slightest evidence of the former presence of petroleum in them. The same holds true for the Carboniferous strata in Western Sinai, and, so far as known, Wadi Araba also, on the Egyptian side.

Summary of Stratigraphical Distribution of Petroleum in Egypt and Sinai.

Petroleum is, or has been, present in the usual lenticular manner in the following formations :—

1. *Miocene Intergypseous Limestone.*—This formation is definitely oil-containing at Hurghada, and may be the one which yielded good supplies at Gemsa. It has also contained petroleum in the past at Ras Dib, and may be the one supplying the seepages at Zeitia. It is of special importance because the oil it contains, which may be described as the Gemsa type, is of light gravity, free from asphalt and rich in benzine.

In seeking for indications of its presence we are guided, not only by the existence of suitable structure, but by that of fetid limestones at the surface, and of sulphur in the gypsum. The writer has never felt it right to recommend areas for development which only show suitable structure; where these additional surface evidences exist, test by boring seems to be justified. It must, however, be noted that these lighter oils have not hitherto been obtained in sufficient quantity to pay for their exploitation.

2. *Lower (or Middle) Miocene Limestone.*—At the base of the gypsum and Globigerina marls in the Zeit range occurs a limestone which has certainly been oil-containing, both at Ras Dib, and in No. 4 bore on the western slope of Gebel Zeit, but the oil in it has not been proved to be present in such quantity as to be of commercial value. Should petroleum be found in paying amounts in this formation beneath the salt-containing anticlines, the oil future in Egypt would be very promising, but up to the present the results have not been of an encouraging nature.

The basal Miocene flint conglomerate has yielded quite important supplies at Hurghada, and may do so elsewhere (the north end of the Zeit range, for example) where surface indications are promising. Unfortunately types Nos. 1 and 2, together with the associated Globigerina marls, are only known in great thickness from a relatively limited area, the conditions seeming to have changed north of Ras Gharib, on the one hand, and south of Desht-el-Dubha on the other. It is possible that the Globigerina marls reappear to the north nearer Suez, but the proof of their existence is at present indefinite.

3. *Cretaceous Sands, Limestones, and Shales.*—These seem to be the most widespread oil-containers in the Egyptian series of rocks, the sand being very fine-grained and the oil supplies protected by thin

layers of clay. The type conditions have been noted in the deeper seated oil-bearing horizons of Hurghada, and are seen on the surface at Abu Durba. Most of the surface occurrences reported by the Petroleum Research expeditions are in these Cretaceous beds, and usually at the point where the fossiliferous strata are passing over into the unfossiliferous sandy facies, the Nubian sandstone. In particular, they may be more especially associated with a definite group of carbonaceous clays, namely, clays containing veins of bituminous material and carbonized remains, a point especially to be borne in mind when considering the origin of the petroleum. Pyrites and sulphur are also commonly present.

The type oil from this series is an asphalt-paraffin containing one of high specific gravity (over ·9) with a fair percentage of sulphur (usually over 2 per cent. See Guthrie, "Preliminary Report on the Chemistry of Egyptian Petroleum, Cairo, 1920"). Certain sedimentary formations, the Jurassic of North Sinai, and Carboniferous of Um Bogma and Wadi Araba are older than those previously described, and are in part very favourably constituted for holding petroleum. Yet the studies made hitherto show them to be devoid of oil-containing formations. Indeed, it was striking to find that such "oil rocks" immediately reappeared in these fossiliferous upper Cretaceous beds, whereas the vast thickness of strata below, otherwise suitable, contained not a trace. We shall return to this point in considering the origin of Egyptian petroleum.

There remain two sources to be mentioned which appear on the evidence at present available to be of secondary importance.

4. There is frequently marked witness in the Eocene beds overlying the Cretaceous to the former presence of petroleum. This is notably the case in the nummulite-containing limestones and beds above them in the fine limestone range north of Wadi Tayiba, and in the Hammam Faraun-Useit Massif. As shown by the late Mr. Barron, these rocks are frequently heavily stained on the borders of igneous dykes. Its former presence in these strata may suggest the existence of underground supplies, but as the rocks themselves are compact, it would probably be difficult to extract the petroleum from them.

5. The Nubian sandstone, as such, has always been very attractive to those who seek for oil, but unfortunately when it has been reached it has usually only yielded water. The only exception where the finer-grained members of it have certainly contained petroleum is at Abu Durba.

As regards its stratigraphical distribution in Egypt, petroleum has been noted in rocks of all ages from the base of the Upper Cretaceous

upwards; it has not been observed in any formations older than the Upper Cretaceous.

Origin of the Petroleum in Egypt.

The absence of any indications of petroleum in the older strata militates strongly against connecting its origin with those deeper-seated processes (alteration of iron carbides, etc.) which have been regarded as its starting-point by many students of this question. After much thought on the subject we must place ourselves in the ranks of those who assign a *vegetable* origin to the oil, and for the following reasons:—

All the data available bear witness to an extremely slow submergence of Egypt and Sinai beneath a sea advancing from the northward, this movement continuing from early Jurassic to late Cretaceous times. The ancient African continent was being eroded, coarse sands being formed near its shores, finer sands and clays being carried further out to sea and deposited there. Finally we reach the margin of detrital influence, where marine organisms live undisturbed by mud-laden waters, and the shells of which, on the death of the animals, by their accumulation on the sea floor, form the limestones. But in addition to the detrital sands and clays, a vast amount of organic material is being brought down, the larger tree trunks being deposited in deltas near the land, and the finer branches and leaves being transported far out to sea. That this was happening in Upper Cretaceous times in Egypt is borne witness to by the thick deposits of Carbonaceous shales which have been traced from Edfu, in the Nile Valley, through Hurghada to the eastern borders of the Sinai Peninsula. These deposits are full of the leaves of plants, now altered to bituminous coal, but the point we urge is that a vast amount of still more comminuted vegetable matter must be carried out farther to sea, and there meeting the finest mud, be carried down by it to the sea-bottom. This plant material would also attract hundreds of minute animal organisms, and thus explain the frequent abundance of the latter in connection with oil deposits. In their turn they attract the fish, so that a certain relationship may also eventually be noted with the existence of the phosphate deposits. Be this as it may, it is in this finely comminuted vegetable material that we see the first stage, which under subsequent earth-changes became converted to liquid petroleum.

Structural Changes in the Egyptian Oil-field Region.

The study of these changes is still almost in its infancy, but it is possible to establish certain broad generalizations on the facts hitherto

ascertained. There is increasing *unconformity* between the Miocene strata and the underlying formations as we advance southward from Suez to the Red Sea. In the area bordering the northern half of the Gulf of Suez the Miocene strata rest on beds of Eocene age of considerable thickness. Further south they lie directly on highly dipping Cretaceous strata (north of the Esh Mellaha range). In south Gebel Zeit the unconformity is with the Nubian sandstone and granite, while finally, in the Red Sea area itself, the Miocene beds directly overlie the ancient igneous and metamorphic rocks.

Such conditions as these would be produced if the strata in the northern part of the Red Sea had been slowly elevated into a low flat arch (or anticlinorium) plunging northward, and, as it rose, being planed down by marine erosion. As the land so rising became continental, it was eroded into hill and dale by the ordinary agencies of weathering, so that when the reinvasion of the sea began in Miocene times by renewed submergence, it had first to fill up the hollows before it overtopped and wore down the ridges. This diversity of land-forms explains the notable *lateral variation* in the character of the Miocene beds themselves. Viewing the matter broadly, on the facts ascertained, we conceive this arm of the ancient Mediterranean as differing but little in surface aspect from the Gulf of Suez or Red Sea of the present day. Reefs bordered its coasts or fringed the islands formed by the old ridges, finally overtopping these as they sank beneath the sea. The depressions between them were first slowly filled by a series of clays and marls derived from the land waste, and these in turn covered by great thicknesses of gypsum or salt, which we presume to have been formed in lagoons. This is but another example of the successive deposition of shallow-water beds during long periods, either indicating a balance between the marine advance and their formation, or an equally steady deepening of the basin containing them.

These variations make the work of the oil geologist in Egypt one of special difficulty. He can never be certain when he advises a bore through Miocene strata as to the character of the beds to be traversed, and especially as to the formations he will reach after passing the uncomfortable junction with the older members of the succession. The increased knowledge being obtained, both by surface study and drilling, may simplify some of the problem, but it will not be in any case an easy one.

In middle Pliocene times this alternation of submergence and emergence, of deposition and erosion, producing these varied stratigraphical results, came to an end. Two main types of folding have been recognized in the region adjoining and including the Clysmic Gulf or Area, which the writer has defined in a recent discussion at the

Geological Society "as the district bordering the Gulf of Suez, and lying between the (largely) fault-bounded ranges of Egypt and Sinai (on the west and east respectively), which dominate this lower lying area. Within its borders Miocene deposits are of wide distribution; beyond them these are notably absent."

We have recently learnt (through the work of Barthoux, Fourtau, Moon, and Sadek) that a series of important north-east and south-west trending folds is present in North Sinai. These folds have their steepest edges facing south-eastward, and strata of from Jurassic to Eocene age inclusive are involved in them. The same type of folding is also found on the Egyptian side of the gulf, the most notable case being the great anticline of Wadi Araba.

We do not know how far this type of folding has entered into the structure of the Clysmic area itself, where a north-west and south-east-trending fold system is the dominant feature. But more striking still is the extent of post-Miocene faulting within its borders. By the complex interplay of fold systems of different periods and the fractures connected with increasing stresses in this area, a number of minor assymetrical anticlines and domes have been produced. We have seen that owing to the variations already referred to drilling on these anticlines and domes is perhaps more uncertain as to results than is the case in many regions of simpler structure.

We can, in fact, divide the present district for oil research into three main areas :—

A. That of the *Red Sea proper*, being the Egyptian coast line south of Kosseir in latitude 26° N. This region is a thin belt of sedimentaries, on an average not much more than four miles in width, which lies between the ancient igneous and metamorphic rocks and the sea. The strata of this belt are in the main not older than the Miocene, and have a gentle eastward dip with a secondary roll into anticlines or domes as the sea is approached. Though various parties have traversed the area, the results have never been published. There are some indications of oil-smelling rocks at the surface in some of these structures, and it is probable that an effort will soon be made to test some of these by boring. The Red Sea area has been claimed as part of a great rift system, where the strata which once occupied its basin have sunk down and been faulted against the igneous core. There is, however, a total absence of evidence of such faulting, the coral reef which forms the base of the Miocene series resting upon the igneous rocks without faulting. Above follows the gypsum-clay series, capped by fossiliferous beds of Pliocene and Pleistocene age. It seems more probable that the surface differences are due to slight local uplift.

B. The conditions are very different in the region which adjoins the Gulf of Suez, and which latter is separated from the Red Sea by a submarine precipice. In the Gulf of Suez depths seldom exceed 40 fathoms, and are more normally 25 fathoms, whereas beyond this line, which crosses obliquely from the southern point of Sinai to the Egyptian coast north of Kosseir, there is a sudden increase in average depth of the Red Sea itself to from 300 to 400 fathoms. We have already mentioned the importance of fracture at the junction of the igneous rocks with the sedimentary formations, and all interested in the subject of oil distribution in Egypt will find abundance of material, both in the earlier Geological Survey works concerning this area by Ball, Barron, and the writer, as well as by the later Petroleum Research studies in which the latter has been associated with Messrs. Madgwick, Moon, and Sadek. Some indication has also been given in preceding pages of the remarkable variations in the underground structures of the numerous minor anticlines and domes which are so especially developed near the southern end of the Gulf of Suez.

C. The mainland of Sinai forms a third area of which the study is only partially completed. The north-east and south-west folds are the most interesting feature in its northern portion, many subsidiary domes being formed along the main anticlinal lines. It still remains to be proved whether the strata which have carried oil in the past still retain it at depth, and if the economic circumstances permit of it we may expect much interesting, and, one would hope, profitable research in this direction during coming seasons.

Oil-field Policy of the Egyptian Government.

Mr. E. M. Dowson, C.B.E., Under-Secretary for Finance, has recently issued a Note on the Programme and Policy of the Egyptian Government. This sets forth in clear terms the nature and extent of the *geological investigation* proposed for locating possible petroliferous areas, as also the distinction between the investigatory boring being carried out for research purposes (as at Abu Durba) and the deep boring undertaken by the Government from a commercial standpoint. It deals further with the internal and external criticism of the Government's policy, and restates clearly what the present policy is in substance. It was also thought desirable to give a summarized history of the petroleum industry, in so far as it is known from the Government records, and to state the exact position as regards the question of coal in Egypt, a subject which has aroused the deepest interest from time to time.

Chemical Study of Egyptian Petroleum.

This branch of study is being continued with close attention in the Government Analytical Laboratory, and the first results have been issued in a "Preliminary Report on the Chemistry of Egyptian Petroleum," by Mr. W. A. Guthrie, M.B.E., etc., to which the attention of those interested is specially directed. The waters encountered in oil-field borings have also been analysed from a very early period of the newer investigations, the data being of use alike to the companies and Government. In the course of examining the results, the writer was struck by the increase in lime and decrease in sulphuric anhydride content with increasing depth, and asked Mr. Beeby Thompson, who was just then leaving for America, to enquire whether they had had similar experiences. The authorities there courteously handed him advance notes of Mr. Rogers' investigations on the oil waters of California, in which the same features had been observed, and the analyses carried out in elaborate detail. The publication of most of our analyses have to be withheld at the moment, because they are so intimately associated with the operations of individual companies, but any results obtained in Government borings will be placed on permanent record.

While mainly dealing with the geological results which have been the subject of his studies for so many years, the writer has endeavoured to indicate the deep interest which the Egyptian Goverment has displayed in investigating its available petroleum resources. He would at the same time place on public record his appreciation of the welcome and hospitality extended to him by the managers and geologists of the Anglo-Egyptian Oil-fields, Ltd., the African Prospecting Syndicate, and other companies. He feels a personal regret that the important work being carried out at Hurghada and elsewhere, as also the observations made by Messrs. C. G. Sara on the islands are not available for publication, the same applying to workers for companies whose studies have been begun more recently.

The President said the members had listened to a paper of exceptional interest, and all would realize what a great work had been done by the author and other members of the Geological Survey of Egypt, as well as by the geologists of the Oil Companies, and what a very important thing it would be if oil was produced in large quantities so close to the great trade route to the East. The Institution was fortunate in having several colleagues of Dr. Hume present, as well as Mr. Cunningham Craig, whom he was sure all the members would be glad

to hear speak on the subject, and he thought it was quite probable that some protagonists of the animal origin of oil as against its vegetable origin might take up the cudgels on behalf of that theory. The author —he thought quite rightly—ruled out the "carbidists," but he did not think Dr. Hume had vanquished the people who believed in the animal origin of oil. He would ask Mr. Cunningham Craig to open the discussion on the paper.

DISCUSSION.

Mr. Cunningham Craig said he wished first of all to express his great pleasure at seeing the author present that evening and hearing his most interesting paper. He used to second the efforts of the late Sir Boverton Redwood in trying to induce the author to give the Institution a paper on the oil-fields of Egypt. At last the Institution had got that paper, and perhaps in one way it might be as well that it did not get it sooner, because the Geological Survey of Egypt had been finding out new facts so rapidly that a paper read two years ago could not have been so interesting as that which had been read on the present occasion. A great part of the country that had been shown in the slides was quite familiar to him personally, and it was with delight that he saw those scenes again. The rocks were so splendidly differentiated and so easy to recognize that the work of mapping really became a very pleasant one. The difficulty arose when structures that were entirely concealed had to be interpreted. The Geological Survey of Egypt was doing most brilliant and unique work by mapping very carefully on a large scale, 1 in 10,000. He would like to pay a little tribute to one or two other gentlemen who had done a great deal in elucidating the problems of Egyptian geology, especially Mr. John Wells and Mr. C. G. Sara. He had had the pleasure of reading what those gentlemen had written on the subject and of studying the problems which they had had to study. The great difficulty was to discover the older movements that had been concealed, and the soundings in the Gulf of Suez had to be studied very carefully. When those interested in the subject began to know a little more about it they discovered that it was only the older anticlines that had trapped and concentrated the oil, and that the younger ones—beautiful as they might be—which only affected the younger strata, were not going to be of any use at all. He was pleased to hear that the author and he were so very much in agreement, especially with regard to the Nubian sandstone and the Cretaceous rocks. The Nubian sandstone, as could be proved in many places, had been an oil rock. It had been a wonderful oil rock. If it could only be got properly sealed up and trapped in a really large anticline somewhere where it had not been disturbed since the first folding movements, one

of the finest oil-fields in the world would be obtained, although the oil might be rather heavy and possibly a little sulphurous. That had not been obtained yet, but those interested in the subject were still hoping for it. He was very delighted to hear the author publicly give the weight of his opinion in favour of the vegetable theory in regard to the origin of oil. There was certainly not conclusive evidence on the subject in Egypt, but there was very distinct evidence, especially, as the author had said, in the Cretaceous strata.

Professor Madgwick said he was sure many of those present realized that the author had given some absolutely new and very important geological information in his paper that evening. The International Geological Map showed Miocene strata where the author had now definitely discovered Jurassic. He appreciated the author's courage in giving his views as to the vegetable origin of oil. There was one very interesting point with regard to structure that he thought would have to be considered very seriously in the near future. It would be noticed that on the last page of the paper the author referred to the much greater depth of the Red Sea as compared with the Gulf of Suez, and said that the normal depth of the Gulf of Suez was 25 fathoms whilst that of the Red Sea was 300 to 400 fathoms. It would also be noticed that the author gave the depth of the Miocene rocks as 1000 metres, roughly 500 fathoms. Therefore at the beginning of the Miocene period the Gulf of Suez might presumably have been the same depth as the Red Sea. One of two theories had to be accepted. One was that for some reason or other the Gulf of Suez became dammed and was filled up with Miocene rocks, and the other was that a large amount of Miocene rocks had been faulted down into the bottom of the Red Sea. He would like to know whether the author had formed any idea as to that possibly large extension of Miocene rocks beneath the Red Sea. There was a variety of possible explanations, and he himself was still rather doubtful on the subject. With regard to the author's remarks about the various oil horizons, in describing the slides he mentioned that there was an oil horizon in Eocene rock, but he did not include that in the summary that was given in the paper. Personally he thought that Eocene horizon was an original source. With regard to Ras Dib, he was not at all certain whether the particular limestone there that had oil on the surface was the Lower Miocene limestone or whether it was the intergypseous limestone, and he would like to have the author's opinion on the matter.

Mr. Beeby Thompson said he felt constrained to say a few words as he had been associated for many years with petroleum work in Egypt, although he had not had a great deal to do with the field geological work, except for a few weeks each year. With regard to

Abu Durba, the structure there did not conform to conventional ideas, and no company which had operated in Egypt had shown the courage to make a drilling test. It was one of those cases in which he felt convinced from the first that there were possibilities of striking a favourable production of oil. A monoclinal dipping series of sandstones and shales were flanking the granite range, and the outcropping sands are so saturated with very heavy oil that it was practically impossible for a great deal of the oil contents to escape after the initial sealing had been effected. Drilling results have demonstrated that oil does exist in useful quantities under those conditions. The well referred to by the author of the paper was sunk within about 150 feet from the outcrop, but other wells have now been sunk farther from the outcrop and have given much better yields of oil free from water. If the beds continued dipping at the same gentle angle he was quite sure that more distant wells would show a still further improvement in the oil production. It was interesting to note that the oil became decidedly lower in density farther down the dip. He was not sufficiently venturesome to embark on a discussion as to whether the oil had an animal or vegetable origin; but it was interesting to note that several papers had been published on the subject. He recalled a paper written by Messrs. Wade and Illingworth some years ago in one of the geological magazines describing how oil was at that moment being formed from matter round the Red Sea coast line. From oozes collected near the coast they had extracted quite a fair quantity of natural oil by solvents. If that oil had not been carried by water currents from some other place, it must have been formed locally, and, if formed locally, it must have originated from animal matter, because there was no vegetable matter to be found locally. No vegetable matter could have been derived from the land, as the region is devoid of vegetation, and seaweeds are extremely rare along the Red Sea coast line. Personally he was rather disposed to think that the oil was carried by currents round the coast from some of the numerous oil outcrops. He considered that no one but the author could have presented the paper in so attractive and interesting a way as Dr. Hume. It was an extremely lucid account of the geological formations in Egypt. The author had, however, not referred to the many difficulties and hardships met with in conducting the work. Dr. Hume was an ardent field man, and he had personally seen him performing mountaineering feats which he was sure many young men would hesitate to attempt.

Mr. Wells said he was not a geologist, but he wished to say a few words about the origin of oil. The author said that oil was of vegetable origin, but if that was so how was it that there was such a great difference between oil from various regions of the world? On the present

occasion the author had been dealing with the oil from one region only, but even there were found oils of an asphaltic base, oils of a paraffin base, and all kinds of mixtures with qualities and properties totally different from one another. He did not think the author's statement was quite conclusive, because he tended to confuse the vegetable and animal origin by saying that the vegetable matter attracted animal organisms, and they in turn attracted fish. Personally he had a feeling that the oil must be of animal, marine, and vegetable origin. It was probable that oils in some parts of the world were purely vegetable, others from marine animals, and others from terrestrial animals. That was just a layman's view, and it would be interesting if experts could come to a decision on the matter.

Mr. Guthrie said there were two distinct types of oil found in Egypt. One was the heavy viscous type found at Hurghada; it occurred in good quantity and was a mixture in almost equal proportions of paraffin and asphaltic base petroleum containing 2 to 3 per cent sulphur, and was rather difficult to refine fully. Lately it had been coming up with a great deal of a very refractory brine emulsion, which was very difficult to de-emulsify, and the Anglo-Egyptian Oil-fields, Limited, had had a good deal of trouble with it. The other oil, of which he wished a great deal more could be found in Egypt, was a light, mobile oil of the Gemsa type. It was one of the best oils he had ever come across, being very light and containing about 55 per cent of petroleum spirit and kerosene, boiling below 290° C., of which approximately 28 per cent was petroleum spirit, boiling below 150° C.

Mr. Guthrie subsequently wrote:—

In amplification of my remarks at the meeting, I would like to add that the oil from the Hurghada field contains 7·73 per cent of paraffin wax (M.P. 117·5° F.), determined by the ether-alcohol precipitation method at 20° C. (the asphalt having been first eliminated), and 10·57 per cent of hard asphalt determined by precipitation from pentane. These are the average of many determinations, and although the oil looks unpromising in many ways the paraffin wax has been extracted on a large experimental laboratory scale without giving any more trouble than was anticipated, having regard to its composition. The yield of dry crude paraffin scale amounted to 6 per cent on the crude, and fair average lubricating oils can be worked up from the paraffin wax filtrate.

The crude oil from the Gemsa field, which has a specific gravity at 15·5° C. of 0·827, contains 4·94 per cent paraffin wax (M.P. 117° F.), and 0·63 per cent hard asphalt, with but 0·65 per cent of sulphur, so that it will be seen at a glance that this is a very high grade oil.

The oil from the first two wells at Abu Durba, where the Government are now drilling, was, as Dr. Hume remarked, of a very heavy nature, having a specific gravity at 15·5° C. of 0·970/·990, and containing little of any value distilling below 290° C. The asphalt content was high, varying from 8 to 11 per cent hard asphalt and the oil contained over 2 per cent of sulphur. This oil also contained about 5 per cent of a waxy resin which the writer believes to be an oxidation product of paraffin wax. This waxy resin is a very stable substance, being unattacked by sulphuric acid, and the writer would be glad to know whether any of the members have come across such a product in any other oil in the course of their investigations. This crude oil from the first wells at Abu Durba was undoubtedly an inspissated and oxygenated product of petroleum, but, as remarked by Mr. A. Beeby Thompson at the meeting, the latest advices from Cairo indicate that a lighter oil has been struck, having a specific gravity below 0·940 at 15·5° C., and "resembling that from the Hurghada field, which contains 5 to 7 per cent petroleum spirit," boiling below 150° C., and 12 to 14 per cent kerosene, boiling between 150° C. and 290° C.

The writer hopes to have the privilege of putting his views on the chemistry and refining of Egyptian crude petroleums before the members of the Institution at the May meeting.

Dr. Hume, in reply, said that Prof. Madgwick gave him the credit of finding the Jurassics in Egypt, but he was sorry to say that was not the case. M. Barthoux, a young Frenchman, found them first, and his (Dr. Hume's) colleagues—Messrs. Fourtan, Moon, and Sadek—worked them out, he subsequently having the privilege of examining the interesting strata with them. With regard to the question of movements raised by Prof. Madgwick, he had come home partly to find out whether he could obtain a clearer understanding of the movements that had taken place in the Red Sea, but the information he had so far received suggested to him that the situation was a very confused one and required at least another twenty years' study before the truth about them could be fully ascertained. He was sorry he had omitted to mention the Eocene beds in the summary in the paper; they were certainly very important in some regions, notably Western Sinai. He was very glad to hear Mr. Beeby Thompson's cheering remarks about Abu Durba. He had been away from Egypt for nearly six months, and although he had heard the information indirectly he had not received it officially, so that he was very glad to hear from Mr. Thompson that the wells at Abu Durba were showing improved results. His remarks about the vegetable origin of oil applied only to Egypt. He did not profess to say what the origin of oil was the whole world over, but he had been led to think that the vegetable theory was probably

the most satisfactory in reference to Egypt. Mr. Wells pointed out that he had mentioned the plant material attracting animal organisms, which in their turn attracted fish. If chemists would allow those to be brought in also as sources of petroleum, the more the merrier! Dr. Hume also thanked Messrs. the Oilfields of Egypt, Ltd., for placing a series of valuable films at his disposal to be used in the preparation of slides for illustrating the paper, and, had time permitted, would have desired to have expressed his appreciation of the very kind remarks made by Mr. Cunningham Craig concerning the Petroleum Research work being undertaken by the Egyptian Government, as well as for his more personal references.

The President, in proposing a hearty vote of thanks to Dr. Hume for his interesting paper, said he was sure the members would wish to express to Dr. Hume their very great appreciation of his kindness in giving the address during what might in a way be regarded as a holiday visit to this country.

The resolution was carried with acclamation, and the meeting terminated.

Notes on the Chemical Nature of Mineral Lubricating Oils.

By A. E. Dunstan and F. B. Thole.

(Abstracted from a Paper read before the British Association.)

The phenomenal increase in the consumption of lubricating oils in recent years has led to much discussion regarding the physical and chemical factors which govern the lubricating value of heavy mineral oils.

Among the physical qualities may be classed flash-point, colloidal nature, viscosity and viscosity-temperature coefficient, and the much-discussed and still unexplained "oiliness" which is probably a resultant of several factors, in particular, perhaps, surface energy.

On the purely chemical side are ranged the oxidizing and decomposing tendencies which lead to gumming and carbonization.

Chemical and physical qualities are of course intimately connected, since both are in general a function of the chemical constitution of the many and varied hydrocarbons composing a mineral lubricating oil.

Some knowledge of the constitution of these compounds, and of the influence of chemical nature on the essential physical qualities of a lubricant is manifestly of the highest importance, but a study of the

published information regarding these two points shows the existence of profound ignorance of the chemistry of the high-boiling components of petroleum. Our present limited knowledge of the subject is derived principally from the researches of Engler, Kharitchov, Holde, Nastyukow, Mabery, and Marcusson.

It appears beyond doubt that the high-boiling fractions of petroleum, irrespective of their place of origin, are complex mixtures containing but a very small percentage of paraffin hydrocarbons of the formula C_nH_{2n+2} and consisting chiefly of compounds whose formulæ range from C_nH_{2n} to C_nH_{2n-6}. A few of these compounds have been isolated by Mabery by repeated fractional distillation of crude American oils, even from a crude so pronouncedly paraffinoid in nature as Pennsylvanian oil.

The origin of these hydrocarbons has given rise to considerable speculation, though it has afforded but little insight into their molecular structure. Engler and Routala have shown that amylene and hexylene, under the influence of heat and pressure, yield a product rich in naphthenes, similar in appearance and in behaviour on heating to Baku cylinder oil. They consider that the polymerized olefine is an intermediate product in the synthesis. Krämer and Spilker offer a similar suggestion, regarding a polymerized decylene as the intermediate compound, which on decomposition yields a paraffin and a hydrocarbon $C_{20}H_{35}$ apparently identical with one of the components of Baku oil, $2(C_{10}H_{20})_2=2C_{10}H_{22}+C_{20}H_{36}$.

Sabatier and Senderens found that the catalytic action of reduced nickel converted acetylene into products resembling lubricating oil, and suggested an inorganic theory of the origin of petroleum. In a previous paper (*J. Inst. Petr. Tech.*, 1918, 4, 191) we pointed out that in no case has the chemical constitution of a component of a lubricating oil been established, but the chemical behaviour of these oils indicate that among the components are unsaturated hydrocarbons (possibly open-chain but more probably naphthenic and polynuclear, or perhaps of both types), saturated hydrocarbons (naphthenic and to some extent polynuclear, but not to any appreciably extent paraffinoid), and aromatic hydrocarbons (to an unknown and possibly a limited extent), together with small amounts of sulphur and oxygen-containing compounds, the latter of which can be isolated, and are, according to Holde, the principal cause of gumming.

Unsaturated compounds constitute between 20 per cent and 40 per cent of most lubricating oils, and are in part removed from the oil by agitation with concentrated sulphuric acid.

Brooks and Humphrey have shown that the higher simple olefines are polymerized by concentrated sulphuric acid yielding a colourless

condensation product which is insoluble in the acid but soluble in hydrocarbons. Small amounts of carbinols, and acid and neutral sulphates are also produced. It follows, therefore, that the olefine contents of a hydrocarbon mixture cannot be determined volumetrically by extraction with sulphuric acid.

When lubricating oils are shaken with concentrated sulphuric acid a heavy tarry mess separates which soon becomes solid. It seems doubtful, therefore, if lubricating oils contain more than a small percentage of true olefine hydrocarbons. This conclusion is strengthened by the fact that, so far as our experience goes, attempts to hydrogenate such oils by the Sabatier method have uniformly failed. It would, therefore, appear that the nature of the unsaturated bodies in lubricating oil is at present an unsolved problem. Nastyukov has shown that in the presence of sulphuric acid, formaldehyde combines with these hydrocarbons, forming insoluble solid compounds termed "formolites." Instead of formaldehyde, methylal or trioxymethylene may be employed, and according to Richardson the same absorption is observed, whether sulphuric acid or the formolite reagent is employed. American oils contain a higher percentage of these unsaturated hydrocarbons than the corresponding Russian oils and also have a higher iodine value.

Nastyukow has suggested that, owing to condensation, complex saturated hydrocarbons are formed—it is well known, for instance, that benzene yields diphenyl methane. If this is so, then the final oil residue does not represent merely a residual oil unacted upon by the reagent, but also contains certain reaction-products.

Marcusson, following up this work, concludes that the lubricating properties of mineral oils are due to those hydrocarbons which are inert to formaldehyde and sulphuric acid, and that the reactive components possess a higher specific gravity, and a lower viscosity than the original oil—conclusions diametrically opposed to those which we ourselves have brought forward.

A partial separation of these unsaturated hydrocarbons from the saturated ones which does not involve their destruction can be achieved by employing their superior solubility in liquid sulphur dioxide. Thus a lubricating oil with an iodine value of 46 on extraction with liquid sulphur dioxide gave a residue with iodine value 33 and an extract with iodine value 73.

A similar effect was achieved by filtration through Fuller's earth, a material which adsorbs unsaturated compounds to a greater degree than saturated compounds. Neither method is sufficiently discriminating to be of use in effecting even an approximate separation of the two types.

The curious iodine value results given by lubricating oils seem to indicate that the unsaturated compounds attacked by sulphuric acid and by formaldehyde do not react readily nor normally with iodine chloride.

The reaction of mineral oils towards iodine differs profoundly from that of fatty oils. Our own experience in the determination of iodine values by means of the Wijs' reagent has indicated that by varying the time and proportion of iodine chloride a given mineral lubricating oil may yield very widely varying values. For example, a Californian mineral oil gave a value of 20 in 2 hours, 40 in 4 hours, 60 in 64 hours, and 80 in 266 hours, whereas rape oil reached a steady value in three minutes. Again, the iodine value of rape oil was found to be practically independent of the amount of Wijs' solution used (provided a fair excess was employed), but with a mineral lubricating oil, an increase in the proportion of reagent to oil invariably augments the iodine value.

The interpretation of these results is difficult when coupled with the reluctance exhibited to hydrogenation; unsaturated glycerides of comparable molecular weight behave quite normally in both respects.

The facts again seem to lead one to the conclusion that the "unsaturated" hydrocarbons in mineral oil consist to a small degree only of true olefines. The sluggish reactivity of the greater part may be due to the slow and somewhat difficult rupture of closed ring systems, which can be brought about by the drastic action of sulphuric acid and Wijs' reagent respectively, whereas the milder reaction of hydrogen and nickel fails to operate.

Analysis indicates that the residual saturated compounds after treatment with concentrated sulphuric acid are principally naphthenic, and most probably polynuclear in structure, since they contain less hydrogen than is demanded by the simple naphthenic formula C_nH_{2n}. Krämer and Spilker studied the effect of heat and pressure on Baku cylinder-oil, on some synthetic aromatic hydrocarbons of high viscosity which they considered typical of the more viscous components of lubricating oil, and on rosin oil rich in open-chain olefinic hydrocarbons. The two latter classes gave products rich in anthracene, while Baku oil gave naphthalene, but no anthracene derivatives. They concluded, therefore, by a process of elimination, that the hydrocarbons of Baku lubricating oil are essentially cyclic compounds, and not polymeric olefines nor aromatic compounds.

Nothing appears to be known regarding the possible presence of aromatic compounds, though Brooks and Bacon have isolated from lubricating oils a minute quantity of material which is the cause of fluorescence or "bloom," and which on this account is presumably aromatic in nature. Nitro-compounds are obtainable by the action of

nitrating acid on mineral oils. The reduction products from these will, however, not yield azo-dyes, so the nitro-compounds may not be aromatic in type. Resinous components have been shown by Holde to be present to the extent of a few parts per cent, and to be capable of separation from the hydrocarbons by treatment with alcohol and ether. They are solid, oxygen-containing lac-like bodies, and are probably an important cause of "gumming" since they would tend to accumulate as the hydrocarbons in the oil evaporated. Moreover, the hydrocarbons thus purified showed no tendency to gum on prolonged exposure to heat and air. Holde's statement would appear to go too far. The removal of these bodies reduced the gumming tendency. Removal of unsaturated hydrocarbons still further reduces it, but even the saturated hydrocarbons oxidize appreciably on exposure to air and heat.

The actual influence on the viscosity of the oil of the differences in chemical nature of the different components has been stated by several workers, the statements being in some cases contradictory. Mabery and Mathews have published figures which indicate conclusively that an increase in viscosity occurs concurrently with a decrease in the hydrogen-content, paraffins being comparatively very mobile and inefficient in lubricating power, while hydrocarbons of the formula C_nH_{2n-4} are said to be as viscous and as efficient as sperm oil.

It is a well-known fact that paraffins are comparatively poor lubricants, while oils such as medicinal paraffin and vaseline, which have been submitted to vigorous refining by acid or filtration generally with the object of decolorizing, are inferior in viscosity and in lubricating efficiency to those which still contain a certain proportion of unsaturated hydrocarbons.

The oil refiner should therefore carefully regulate the treatment given so as to remove as far as possible the oxygenated compounds and the more highly reactive of the unsaturated hydrocarbons which are chiefly responsible for gumming and carbonization, while destroying only a minimum of those more stable unsaturated hydrocarbons whose presence in the oil is an asset.

The System Ethyl Alcohol—Water—Aromatic Hydrocarbons from 30° C. to −30° C.

By W. R. Ormandy and E. C. Craven.

The question of the equilibrium relations in ternary liquid mixtures is one of considerable general theoretic interest and has been studied by many observers. Those systems which include ethyl alcohol and the more common hydrocarbons are also of practical importance in view of the increasing employment of such mixtures as fuels for internal-combustion engines. Of these hydrocarbons benzene and its homologues, by reason of their miscibility with alcohol and their commercial importance, are of special interest.

Dealing first with the binary systems of the bodies under consideration, two of these hardly fall within the scope of the work. The mixture alcohol-water has been thoroughly investigated by many workers over a wide range of physical properties. At −30° C. mixtures containing more than 39·9 per cent (Pickering, *J. Chem. Soc.*, 1893, **63**, 1016) by weight of alcohol do not freeze. In such a mixture the commoner hydrocarbons are soluble only to a small extent.

Again, in regard to the binary mixtures of water and hydrocarbons, the mutual solubilities are in all cases excessively small and need not be considered here.

In the case of the systems hydrocarbons—alcohol it is otherwise. The freezing points of the various components are as follows :—

Benzene	5·49° C.	Sidgwick (*J. Chem. Soc.*, 1920, **144**, 1340).
Toluene	−94·5° C.	Timmermans (*Bull. Soc. Chem. Belg.*, 25, 316).
Xylene o	−28° C.	Various.
„ m	−54° C.	
„ p	16° C.	
Ethyl alcohol	−144·2° C.	Timmermans (loc. cit.).

The binary mixture alcohol-benzene has been investigated by Pickering (*J. Chem. Soc.*, 1893, **63**, 1015). The depression of the freezing point of benzene falls away very rapidly from the simple cryoscopic law and presents other features not without a bearing on the present work.

The strongest alcohol employed in the present research was of 99·3 per cent weight strength. The results, however, are in line with those of Pickering. In consequence of the smallness of the freezing point depression effect of alcohol on benzene, combined with the anomalous effect of water on such mixtures, it is found that the triple points of these mixtures are never far below the freezing point of benzene.

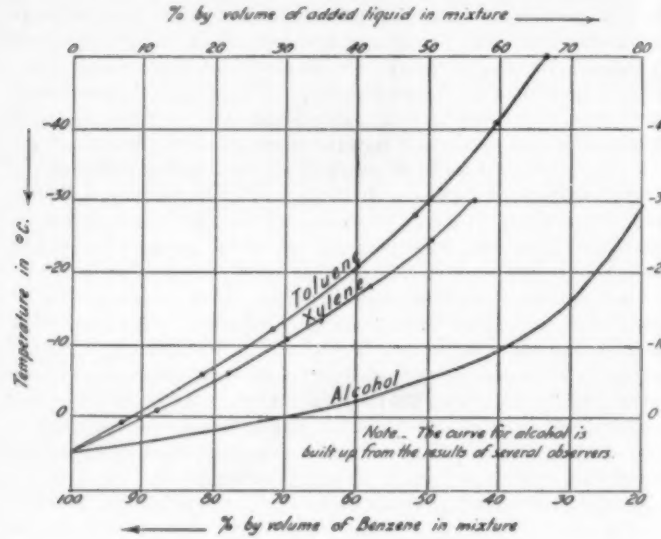
No literature appears to be available on the freezing points of the binary mixtures of alcohol with the xylenes. It was hoped that it would be possible to obtain specimens of the three isomers and to determine the freezing point curves of the ortho and para bodies, but samples have not yet been forthcoming.

The literature on the subject of the ternary system benzene-alcohol-water has been dealt with very thoroughly by Sidgwick and Spurrell in their recent work on this subject (*J. Chem. Soc.*, 1920, **117**, 1397). It has not been thought necessary to go over the whole of the ground already covered by these workers, but the results have been extended to lower temperatures as already defined. A certain amount of repetition is unavoidable, but for a full treatment the present work must be read in conjunction with the paper by these workers.

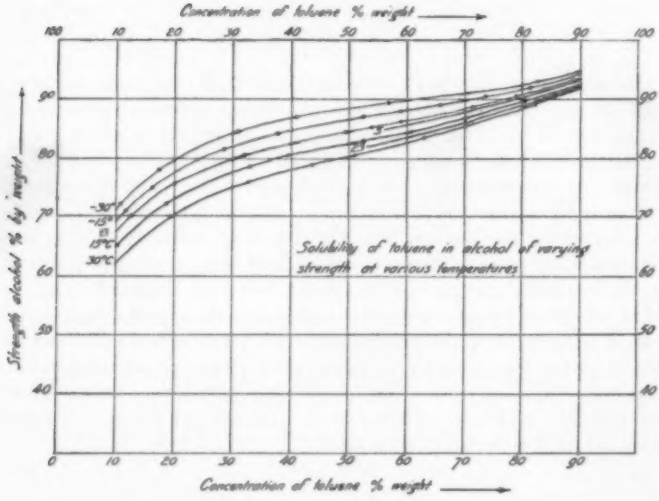
On the ternary mixtures containing toluene or xylenes the literature is very scanty. Bonner (*J. Phys. Chem.*, 1910, 779) gives curves for toluene and the three xylenes each at one temperature only. The system m-xylene-alcohol-water has been investigated by Holt and Bell (*J. Chem. Soc.*, 1914, **105**, 633). Curves are given of the solubilities at several temperatures together with some figures relating to the composition of two phases in equilibrium. The results are discussed later.

Experimental.

Methods of Investigation.—The methods of investigating the composition of triple mixtures fall into two groups, the analytic and the synthetic. In the first case the three bodies may be mixed together at the required temperature and allowed to separate into two layers which may be separately analysed by chemical and physical methods. In the synthetic method known weights of two of the components are mixed and the third added little by little until turbidity or complete solution takes place. The synthetic method being the most rapid and accurate was the one adopted in this present work, particularly as we were not concerned with the position of the tie lines on the equilibrium curves but only with the latter themselves. Two courses are open in regard to the temperature. We may work at a constant temperature and vary the composition until separation just occurs, or the composition may be kept constant and the temperature raised or lowered until solution or separation occurs.


% by volume of added liquid in mixture
Temperature in °C.
Toluene
Xylene
Alcohol
Note. The curve for alcohol is built up from the results of several observers.
% by volume of Benzene in mixture

Freezing Point Curves of Mixtures of Benzene with a Second Liquid



In the first experiments performed with toluene and aqueous alcohol this latter method was tried, but it was soon found that unless a very considerable proportion of water was present the temperature of liquid separation was very ill defined. This appears to have been the experience of other observers; Sidgwick and Spurrell, for example, do not give any liquid separation points for the higher alcohol strengths.

It was found in a general way that toluene and the aqueous alcohol behave very similarly to a binary mixture of two partially miscible liquids. At each temperature below the critical there exist two mixtures, the three components of each mixture being in equilibrium at the given temperature.

In consequence of the poor agreement of the results the method of working at constant temperature was therefore tried. Previous workers have used the method of adding known amounts of strong alcohol to the hydrocarbon under examination and then adding water drop by drop under stirring until separation occurred.* In effect this method was adopted, but with the improvement of using dilute alcohol instead of water in order to obtain finer addition of the latter.

The details of working will be given after the description of the apparatus used and the preparation of the liquids employed.

Preparation, Etc., of Liquids.

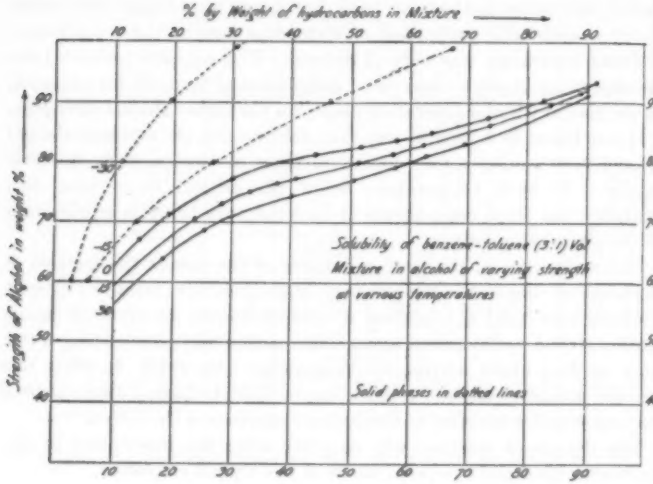
Alcohol.—Absolute alcohol as bought from the chemical dealers was used and was of about 99 per cent weight strength. Portions of this were diluted from time to time as required to give the weaker alcohols employed. For the liquid separations, alcohol of 50 per cent strength was employed in conjunction with the strong alcohol. S.G's were determined by means of the pyknometer and the strengths calculated from the tables of the Imperial Commission given in the *Chemists' Year Book*, pp. 375, 381.

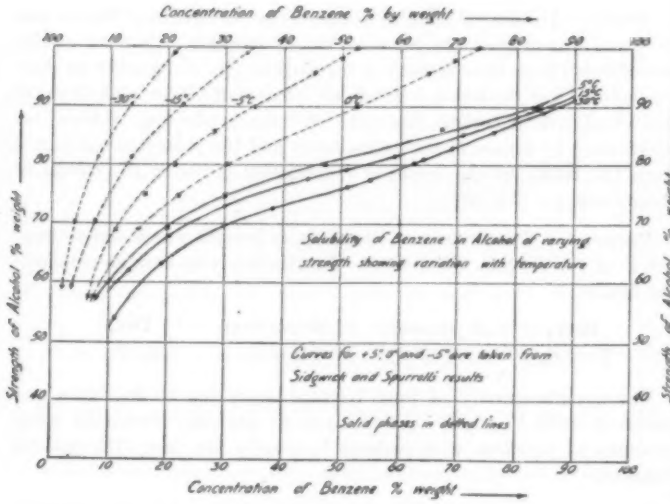
Benzene.—"Thiophene free" benzene as bought was found to have a F.P. of 4·9° C., S.G. ·8832 15/15. Distillation from flask gave following figures:—

Drop.	5 per cent.	90 per cent.	Dry.
79·3° C.	80·0° C.	82·0° C.	86° C.

The specific gravity of pure benzene according to Spielman and others is ·8845 15/15, so that this sample probably contained small amounts of paraffins as is perhaps invariably the case with coal-tar benzene.

* E.g. Bancroft, *Phys. Rev.* 3, 31, 1895–6. Holt and Bell, *J. Chem. Soc.*, 1914, **105**, 633.


% by Weight of hydrocarbons in Mixture
Strength of Alcohol in weight %
Solubility of benzene-toluene (3:1) Vol Mixture in alcohol of varying strength at various temperatures
Solid phases in dotted lines


Concentration of Benzene % by weight
Strength of Alcohol % weight
Solubility of Benzene in Alcohol of varying strength showing variation with temperature
Curves for +5° 0° and -5° are taken from Sidgwick and Spurrell's results
Solid phases in dotted lines

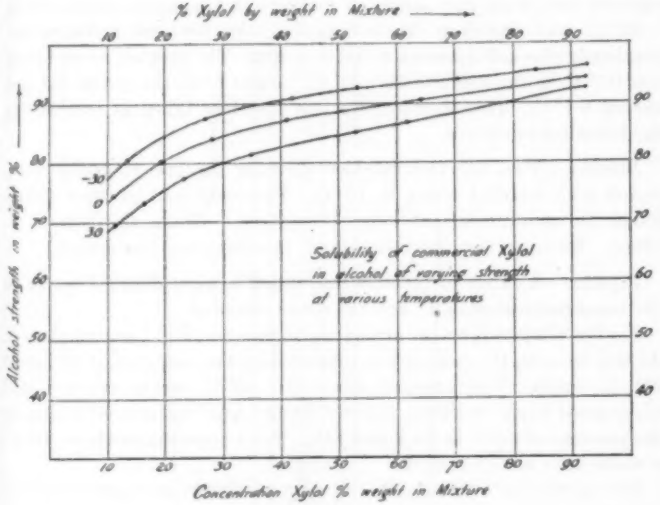
The bulk of the benzene was fractionated through a 6 bulb column and a middle 80 per cent collected distilling between 80·4° and 80·6° C. Barom. 763 mm.

The F.P. of the distilled material was 5·2° C., but the S.G. was unchanged. Sidgwick finds that the F.P. of pure benzene is 5.49° C. when dry and 5·39° C. when wet. It was thought therefore that the distilled material was pure enough for the present purpose without further treatment.

Toluene.—A middle 80 per cent was fractionated from a bottle of "Pure" of unknown origin. The following figures were obtained :—

S.G. before distillation 0·8680 15/15° C.

S.G. after distillation 0·8679.


% Xylol by weight in Mixture
Alcohol strength in weight %
Strength of Alcohol % weight
Solubility of commercial Xylol in alcohol of varying strength at various temperatures
-30
0
30
Concentration Xylol % weight in Mixture

Distillation from flask :—

	Drop.	5 per cent.	90 per cent.	Dry.
Orig.	109·0° C.	110·0° C.	111·0° C.	112·3° C.
Purif.	109·0° C.	110·3° C.	111·0° C.	111·7° C.

The S.G. appears to be slightly lower than some observers have given for the pure body, but there is a want of agreement amongst the recorded values.

Xylol.—Samples of the isolated isomers being unobtainable, a commercial xylol was used, having the following characters :—

S.G. 0·8665 15/15° C.

Distillation from flask :—

Drop.	5 per cent.	50 per cent.	90 per cent.	Dry
138° C.	139·5° C.	140·4° C.	145° C.	148° C.

Apparatus.

The thermometers used were checked down to 0° C. against standard instruments with Reichanstalt certificates, the zero point of the standard thermometers being redetermined. (In nineteen years ice-point had risen 0·05° C.) For temperatures below 15° C. a pentane thermometer was purchased, but it was found that the corrections for exposed stem were very large. A mercury thermometer graduated to −30° C. was therefore checked against the pentane thermometer previously checked against ice and mercury. The greatest error found was 0·2° C. in the region −30°—0° C. Above 0° C. the errors did not exceed 0·1° C. This thermometer was therefore taken as correct for the lower temperatures.

Burettes.—Two burettes marked specially for standardizing were tested with distilled water at 15° C. The mean and greatest errors found for each instrument were—(1) ·005 cc.—·04 cc., (2) 0·010 cc.—·03 cc. No correction was attempted, therefore, for graduation.

Pipettes.—A range of pipettes was tested against distilled water in the usual manner at 15° C. and the errors recorded.

For low temperatures the arrangement shown in Fig. 1 was employed. As will be seen, the cooling was produced by the evaporation of liquid SO_2 in vacuo. Temperatures down to −50° C. can be reached and maintained fairly steadily. Some difficulty was experienced owing to the presence of water in the liquid SO_2. For temperatures above 10° C. a water bath was employed.

The method of working in the case of either arrangement is as follows :—

5 cc. or 20 cc. of the hydrocarbon to be tested are pipetted, at a known temperature near 15° C., into the mixing tube and brought to the desired temperature by the bath. The burettes are charged with the strong and weak alcohols respectively and the readings taken. The temperature of the alcohols is noted by means of a small thermometer in the lower portion of the burette. A small amount of strong alcohol is run in, followed by the weak alcohol, drop by drop, until turbidity appears imminent. The temperature is then adjusted

exactly and addition of one drop of weak alcohol then usually gives dense turbidity. The readings are taken and the operations repeated until the required dilution of hydrocarbon has been reached. A dozen readings can be taken in as many minutes. Special tests made showed

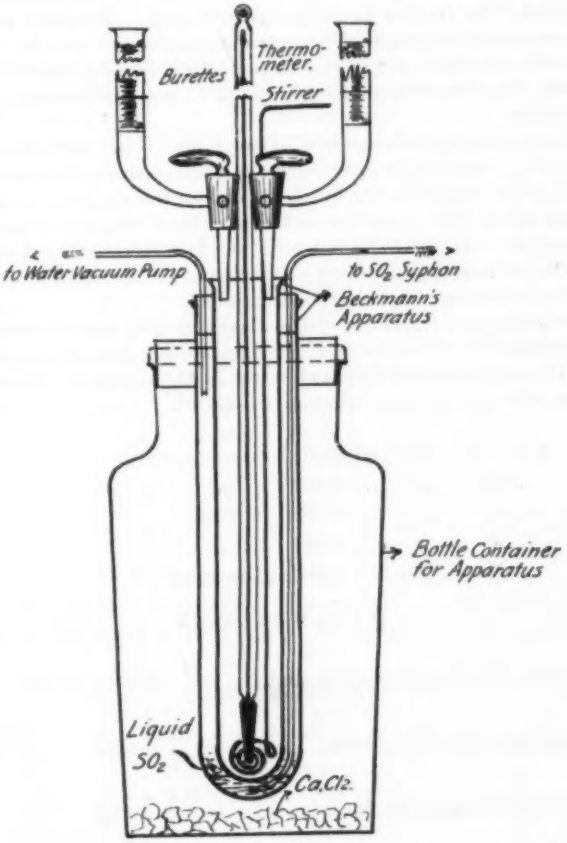


Fig. 1.

that the influence of evaporation and atmospheric moisture was entirely negligible in the short time required for each test. The turbidity point is very distinct except when less than 10 per cent or more than 90 per cent of alcohol is present, and one drop (0·02 cc.) of

weak alcohol corresponding to about 0·01 gms. water usually converts a clear solution into one opaque in $\frac{1}{2}$" layer. One to three drops of strong alcohol suffice to clear the turbid suspension again.

In the case of freezing point curves, whether of two hydrocarbons or of one hydrocarbon with a single strength of alcohol, one burette only was used. The freezing points were determined in the usual manner and each point repeated. The repeat measures were usually 0·1° C. higher than the first, and in such cases the higher reading was taken as correct. In a few cases a difference of 0·2° C. was found and the mean was taken.

The method of calculation is as follows: The volume of hydrocarbon pipetted is corrected for pipette error and temperature difference from 15° C., when multiplication by the S.G. gives the weight H of hydrocarbon taken. The expansion coefficient of the hydrocarbons has been assumed in every case to be ·001 per 1° C. This is probably not exactly correct, but as all liquids were kept within two or three degrees of 15° C. no great error can arise from the assumption.

The volumes of the strong and weak alcohol added are corrected for temperature by the tables to which reference has already been made, and the weights of alcohol and water in the corrected volumes of strong and weak alcohols taken are calculated.

Let A be weight of alcohol in strong spirit.
" W " " water " "
" a " " alcohol in weak "
" w " " water " "
" H " " hydrocarbon taken.

$$H+A+W+a+w=\Sigma$$

Then per cent of hydrocarbon in mixt. $=\frac{H}{\Sigma}\times 100$ by weight.

and per cent of alcohol in mixt. $=\frac{A+a}{\Sigma}\times 100$

and per cent of water in mixt. $=\frac{W+w}{\Sigma}\times 100$

and strength of alcohol in weight per cent $=\frac{A+a}{\Sigma-H}\times 100$

These values are calculated for each set of readings taken and the results are tabulated and graphed.

The results obtained are tabulated below :—

Freezing Point Curves of Binary Mixtures.

BENZENE+SECOND LIQUID. F.P. OF BENZENE USED 5·2° C.

TABLE I.		TABLE II.		TABLE III.	
Alcohol 99·3% wt. strength.		Toluene.		Xylene (mixture o, m, p).	
Per cent wt.		Per cent wt.		Per cent wt.	
Alcohol.	F.P.° C.	Toluene.	F.P.° C.	Xylol.	F.P.° C.
61·6	−11·4	2·7	3·5	11·9	−1·0
64·3	−13·3	7·0	1·1	29·7	−10·9
66·7	−15·3	12·6	−2·2	35·8	−14·9
68·9	−17·3	18·3	−5·8	43·1	−19·8
71·0	−19·3	23·4	−8·8	49·6	−24·7
72·9	−21·4	28·0	−12·3	56·1	−30·0
75·0	−24·1	32·6	−15·4		
76·4	−26·0	36·3	−18·3		
78·7	−29·4	39·8	−20·8		
79·3	−30·5	43·4	−24·0		
		46·6	−27·1		
		48·0	−28·2		
		59·7	−40·6		
		66·3	−50		

Freezing Points of Ternary Mixtures.

The strength of alcohol is given in weight per cent. B=per cent by weight of benzene in mixture. F.P.=Temp. of first solid separation in ° C.

TABLE IV. BENZENE—ALCOHOL—WATER.

Alcohol 99·3 per cent.		Alcohol 90·3 per cent.		Alcohol 80·3 per cent.		Alcohol 70·3 per cent.		Alcohol 59·3 per cent.	
B.	F.P.	B.	F.P.	B.	F.P.	B.	F.P.	B.	F.P.
38·4	−11·4	26·9	−10·2	15·1	−11·8	9·1	− 9·6	5·2	− 6·7
35·7	−13·3	24·5	−12·1	11·9	−16·9	7·4	−14·9	3·9	−12·5
33·3	−15·3	22·4	−14·3	10·6	−19·9			3·1	−18·1
31·1	−17·3	20·1	−17·1	9·5	−22·4			2·6	−22·5
29·0	−19·3	17·9	−19·9	8·6	−25·4			2·2	−26·2
27·1	−21·4	16·4	−22·8	7·6	−29·0			1·9	−30·1
27·0	−24·1	14·9	−26·0	7·3	−30·6				
23·6	−26·0	13·7	−29·0						
21·3	−29·4	13·3	−30·1						
20·7	−30·5								

TABLE V. BENZENE—TOLUENE MIXTURE (3 : 1 VOLUME)—ALCOHOL—WATER.

Alcohol 99·0 per cent.		Alcohol 90·3 per cent.		Alcohol 80·3 per cent.		Alcohol 70·3 per cent.		Alcohol 60·4 per cent.	
B.-T.	F.P.	B.-T.	F.P.	B.-T.	F.P.	B.-T.	F.P.	B.-T.	F.P.
84·7	−12·9	77·8	−12·3	31·8	−13·7	14·2	−15·0	5·8	−17·5
73·8	−14·2	63·6	−13·0	28·2	−14·5	12·4	−16·7	5·0	−20·1
64·9	−15·6	52·1	−14·3	24·2	−16·2	10·4	−19·7	4·4	−22·4
55·3	−17·6	42·0	−16·2	21·4	−17·7	8·8	−22·0	3·9	−24·8
47·7	−20·1	34·1	−19·0	19·5	−19·9	7·4	−25·7	3·5	−27·0
42·0	−22·7	28·7	−21·9	16·2	−22·2	5·9	−30·6	2·9	−31·2
37·6	−25·3	24·7	−25·0	14·4	−24·4				
34·0	−27·4	21·6	−28·0	12·2	−28·2				
30·9	−30·4	19·8	−29·9	10·9	−30·5				

Liquid Separation Points of Ternary Mixture.

Hydrocarbons given in per cent by weight in mixture. Alcohol strengths in weight per cent.

BENZENE—ALCOHOL—WATER.

TABLE VI. 30° C.

Per cent.	
Benzene.	Alcohol.
63·13	80·75
38·17	72·61
18·68	63·29

TABLE VII. 25° C.

Per cent.		Per cent.	
Benzene.	Alcohol.	Benzene.	Alcohol.
96·06	93·14	97·13	95·11
90·00	91·20	90·53	91·86
84·01	88·91	80·60	87·98
76·46	85·98	76·48	86·52
69·32	83·25	71·00	84·71
61·97	80·45	67·02	82·99
55·03	77·91	62·52	81·34
50·99	76·57	58·33	79·83
		54·24	78·44
		51·23	77·58

TABLE VIII. 15° C.

Per cent.		Per cent.		Per cent.	
Benzene.	Alcohol.	Benzene.	Alcohol.	Benzene.	Alcohol.
97·20	92·48	97·10	92·74	64·79	84·35
92·79	93·05	92·13	92·88	44·04	77·97
87·78	91·31	87·75	91·18	36·66	75·60
83·25	89·66	82·92	89·22	30·01	72·96
78·79	88·12	78·75	87·94	20·66	68·17
74·48	86·43	74·36	86·38	18·25	66·15
70·36	85·31	70·36	85·07	13·08	62·03
65·08	83·50	62·72	82·64		
59·35	81·62	55·66	80·52		
55·19	80·47	50·85	79·23		
51·00	79·32	46·78	78·29		
47·36	78·44				

TOLUENE—ALCOHOL—WATER.

TABLE IX. 30° C.

Per cent.		Per cent.	
Toluene.	Alcohol.	Toluene.	Alcohol.
63·00	83·30	94·47	94·39
43·76	78·56	88·13	91·75
32·62	75·59	82·14	89·47
23·36	71·90	75·22	87·17
19·65	69·93	68·39	84·96
13·00	65·16	62·79	83·31
8·89	60·97	57·73	81·92
		53·11	80·78
		50·97	80·32

TABLE X. 25° C.

Per cent.	
Toluene.	Alcohol.
97·05	92·50
92·46	93·21
87·05	90·83
82·19	89·55
78·21	88·41
73·65	86·97
69·64	85·82
64·87	84·47
59·72	83·11
56·69	82·55
52·96	81·53

TABLE XI. 15° C.

Per cent.		Per cent.		Per cent.	
Toluene.	Alcohol.	Toluene.	Alcohol.	Toluene.	Alcohol.
97·03	90·88	97·31	97·39	65·94	85·52
92·60	92·82	94·11	95·23	46·04	81·73
87·86	93·31	89·45	92·52	39·49	80·27
82·93	90·33	85·35	91·37	33·06	78·45
78·80	89·10	80·39	89·43	28·34	76·92
74·91	88·19	76·70	88·58	22·35	74·23
70·00	86·67	70·89	86·84	18·44	72·02
64·94	85·30	66·84	86·09	15·10	69·62
58·90	83·95	60·43	84·45	11·32	66·19
54·52	83·32	55·72	83·58	10·24	65·05
48·86	82·32	52·37	82·97		
45·39	81·55				

TABLE XII. 5° C.

Per cent.		Per cent.		Per cent.	
Toluene.	Alcohol.	Toluene.	Alcohol.	Toluene.	Alcohol.
97·20	95·71	96·87	95·84	64·60	87·18
90·72	93·56	92·12	94·17	61·87	83·21
85·35	91·42	85·50	92·41	31·57	78·20
79·62	89·70	78·82	90·51	20·06	75·56
73·59	88·67	71·21	88·56	13·13	70·27
68·45	87·41	64·81	87·36		
63·71	86·47	58·81	86·17		
59·21	85·57	53·84	85·36		
55·55	84·95	49·50	84·65		

TABLE XIII. 0° C.

TABLE XIV. −15° C.

Per cent.		Per cent.	
Toluene.	Alcohol.	Toluene.	Alcohol.
92·51	94·26	97·06	95·91
81·98	90·95	90·84	94·22
53·76	87·02	81·68	91·97
38·03	84·28	73·17	90·57
28·60	81·38	65·51	89·06
21·86	78·46	59·08	88·12
16·26	75·01	52·39	87·27
11·49	71·05	46·38	86·16
8·40	67·58		

TABLE XV. −30° C.

Per cent.	
Toluene.	Alcohol.
92·86	96·77
82·67	92·90
56·67	89·12
40·72	86·83
30·81	84·17
22·87	80·92
17·83	78·12
14·56	75·80
10·37	71·64
9·56	70·91

Benzene—Toluene—Alcohol—Water.*

The hydrocarbons used in this series consisted of a mixture of 3 vols. of benzene to 1 vol. of toluene.

Table XVI. 30° C.

Per cent. Hydrocarbon.	Per cent. Alcohol.
97·04	94·26
90·16	91·66
83·94	89·16
76·90	86·36
69·35	83·62
63·06	81·40
57·13	79·31
50·37	77·18

Table XVII. 25° C.

Per cent. Hydrocarbon.	Per cent. Alcohol.
62·02	80·90
40·20	74·36
25·12	68·64
18·23	64·57

Per cent. Hydrocarbon.	Per cent. Alcohol.
96·83	91·80
92·14	92·21
86·91	90·37
82·36	88·65
76·83	86·69
71·91	85·07
66·69	83·12
61·58	81·48
56·14	79·77
	78·48

Table XVIII. 15° C.

Per cent. Hydrocarbons.	Per cent. Alcohol.
97·44	92·56
93·02	93·37
88·36	91·40
83·70	89·50
79·12	88·26
72·24	86·01
68·83	84·81
62·69	83·09
58·12	81·87
53·69	80·77
51·01	80·09

Per cent. Hydrocarbons.	Per cent. Alcohol.
97·10	94·12
91·65	92·69
86·51	90·88
81·19	88·93
76·87	87·67
72·15	86·17
66·71	84·37
61·66	82·88
56·95	81·53
51·08	80·08

Per cent. Hydrocarbons.	Per cent. Alcohol.
63·41	83·25
40·64	77·43
33·90	75·31
28·27	73·19
23·06	70·58
16·84	64·65

* These are not really ternary mixtures, but the benzene-toluene mixture may be regarded as a unit.

TABLE XIX. 0° C.

Per cent. Hydrocarbons.	Alcohol.
96·49	96·58
91·18	93·30
82·31	90·33
73·33	87·69
63·69	85·32
58·12	84·10
51·55	82·73
49·37	82·32

TABLE XX. −15° C.

Per cent. Hydrocarbons.	Alcohol.
63·91	85·31
44·13	81·11
30·92	77·24
19·27	71·26
13·93	66·93

Per cent. Hydrocarbons.	Alcohol.
16·43	71·70
14·32	69·94
12·34	68·06
10·30	65·93

XYLOL—ALCOHOL—WATER.

TABLE XXI. 30° C.

Per cent. Xylol.	Alcohol.
92·22	91·90
82·67	92·20
52·01	84·68
34·70	81·30
23·12	77·24
15·77	73·00
11·45	69·40
8·67	66·55

TABLE XXII. 0° C.

Per cent. Xylol.	Alcohol.
92·67	93·72
83·18	93·90
64·09	90·24
40·92	87·24
28·02	84·05
19·57	80·33
14·39	76·97
11·25	74·24
9·47	72·35

TABLE XXIII. −30° C.

Per cent. Xylol.	Alcohol.
92·87	96·20
83·87	95·66
70·77	94·11
53·49	92·66
41·89	90·90
26·73	87·14
22·20	85·46
17·40	82·96
13·92	80·60
11·59	78·65
9·84	76·86

Discussion of Results.

In regard to the binary mixtures of benzene with toluene, an examination of the results shows that, as might be expected with bodies of such similar character, the depression of freezing point of benzene follows the cryoscopic law over a considerable range (within 0·5° C. up to 20 per cent toluene or xylene added). As a point of practical interest it may be remarked that the National Benzole Association specifies a freezing point of 7° F. (−13·9° C.) for motor benzol. This corresponds according to present results to a mixture of 69·5 vols. benzene with 30·5 vols. toluene or 65·3 vols. benzene with 34·7 vols. xylol. These figures correspond approximately with the "80"s benzol of commerce.

Pickering (loc. cit.) found that the depression of the freezing point of benzene by alcohols departs farther from the theoretical curve, the lower the alcohol is in the series.

An exterpolation of the values obtained for 99·3 per cent weight alcohol gives the following figures for pure alcohol :—

Freezing point . .	−10° C.	−15° C.	−20° C.	−25° C.	−30° C.
Per cent wt. benzene in mixture . .	42·4	34·2	29·2	24·9	21·5
Per cent wt. benzene in mixture (Pickering)	42·5	35·8	30·8	27·0	23·8

Coming to the ternary systems, the first has been considered in detail, as before stated, by Sidgwick and Spurrell. The following table showing the strengths of alcohol necessary to dissolve various proportions of benzene at 15° C. collected by graphical interpolation may be of interest :—

Table XXIV. Benzene at 15° C.

	Per cent by weight Benzene in Mixture.								
	10	20	30	40	50	60	70	80	90
(1)	58·5	67·9	72·9	76·7	79·3	82·0	85·1	88·4	92·3
(2)	58·8	68·0	73·1	76·7	79·6	82·5	85·3	90·0	—
(3)	59·1	67·8	72·6	76·4	79·8	82·7	85·4	88·4	92·3
(4)	57·0	67·0	72·3	76·1	78·9	81·2	84·1	88·4	—

(1) Present work. (2) Bonner. (3) Taylor (corrected from 25° C. to 15° C.). (4) Sidgwick and Spurrell.*

* With regard to the discussion by Sidgwick and Spurrell there appears to be some slight confusion among some of the figures given. It is stated on page 1404 that the composition of the mixture at the lowest triple point (2·52° C.) is 80 per cent benzene and 2 per cent water, whereas the author's own figure, page 1401,

The results on toluene and xylol require very little comment. The freezing point of these bodies being below —30° C., no separation of solid phase could take place with the triple mixtures down to the lowest temperature employed. It will be noticed that at any temperature above the melting point of benzene the solubilities of the three hydrocarbons in an alcohol of any given strength, are in the order benzene—toluene—xylol. At temperatures below the melting point of benzene, separation of solid phase occurs and the solubility of benzene falls below that of the two homologues.

A comparison of the results obtained with those of other workers collected by graphical interpolation is given below :—

TABLE XXV. TOLUENE AT 15° C.

	Per cent by weight Toluene in Mixture.								
	10	20	30	40	50	60	70	80	90
	Strength of Alcohol weight per cent.								
(1)	67·7	75·3	79·5	82·2	84·5	86·4	88·2	90·5	93·5
(2)	68·9	75·1	79·8	82·9	84·9	86·5	(88·6)*	—	—

(1) Present work. (2) Bonner.

TABLE XXVI. XYLENES 0° C.

	Per cent by weight Xylene in Mixture.								
	10	20	30	40	50	60	70	80	90
	Strength of Alcohol per cent weight.								
(1)	73·0	80·4	84·4	87·0	88·6	89·9	91·4	92·4	93·9
(2)	m. 75·0	82·4	86·0	88·2	90·1	91·2	(91·7)*	—	—
(3)	o. 73·1	80·2	84·8	88·2	91·0	92·7	92·8	—	—
	m. 74·1	80·5	84·6	87·6	90·0	91·3	(92·3)*	—	—
	p. 72·7	80·2	84·0	86·5	88·3	89·8	91·6	—	—

(1) Present work xylol. (2) Holt and Bell. (3) Bonner. Note—results for p. xylene corrected from 15° C. to 0° C.

In the last system dealt with a mixture of benzene and toluene was employed as the hydrocarbon component. The proportion employed is 44·95 per cent. This composition is further supposed to indicate the plait point, it being stated that Taylor at 25° C. found at the plait point 80·2 per cent benzene. An examination of Taylor's figures shows that the plait point is somewhere near 55 per cent benzene. Bonner (loc. cit.) places the plait point at 60 per cent benzene which seems to confirm Taylor's result.

* All figures in brackets are exterpolated values.

was 3 vols. of benzene to 1 vol. of toluene, it being thought that this would approximate to the composition of a motor benzol. The freezing point of this mixture is −10·1° C. and it may be noted that the effect of this depression of the freezing point of benzene increases the solubility at low temperatures.

Although specific determinations of the triple points with various strengths of alcohol were not made, the following figures show the order of these temperatures:—

In 99·0 per cent alcohol .	liquid separation . .		−12·9° C.
„ „ „ .	solid „ . .		−14·2° C.
In 90·3 „ „ .	liquid „ . .		−10·1° C.
„ „ „ .	solid „ . .		−12·3° C.
In 80·3 „ „ .	„ „ . .		−13·7° C.
In 70·3 „ „ .	„ „ . .		−15·0° C.
In 60·3 „ „ .	„ „ . .		−14·5° C.

It will also be observed that liquid separations at −15° C. were obtained in alcohol varying in strength from 65·93 to 71·70 per cent. A portion of this curve is probably in a meta-stable region, but there is a break about 69 per cent alcohol strength which seems to indicate a triple point of −15° C. at that strength of alcohol.

These figures would seem to indicate a greater difference between the freezing point of the original hydrocarbon mixture and the lowest triple point than is the case with benzene.

This work is being extended to the solubility of pure paraffin hydrocarbons in alcohol, both alone and in admixture with aromatic hydrocarbons. Determinations are also being made of the freezing points of mixtures of the paraffins with the aromatic hydrocarbons. It is intended to extend this work to an examination of the behaviour of the better-known commercial petrols and paraffins. The whole research is being carried out at the joint request of the Distillers' Company, Ltd., and the Fuel Research Board of the Department of Scientific and Industrial Research, who have jointly provided the funds necessary for the work.

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PLAUSON (COLLOID MILL) PROCESS FOR THE PRODUCTION OF COLLOIDS, AND ITS TECHNICAL APPLICATION, THE.—A. Chwala. *Oesterr. Chem. Zeit.* **24,** 107. *J. Soc. Chem. Ind.* **40,** 647A.

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REMARKABLE OIL IN BY-PRODUCT SANDS AND OUTCROPS.—A. R. Elliott. *U.S. Bur. Mines Rept. Investigations*, 2182. *Chem. Abstr.* **15,** 1615.

SOLIDIFICATION OF OILS, THE.—F. Fritz. *Kunststoffe* **11,** 50. *Chem. Age* **5,** 135.

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Abstracts.

Compiled by T. A. Smith, B.Sc., F.I.C.

Paraffin Wax. Preparation and Oxidation Products of.—A. Saarschnidt & M. Thiele. Ber., 1920, 53. 2128–43.

Paraffin wax was treated with chlorine at 160° C., the current of gas being finely divided by means of a Witt's stirrer. The reaction which proceeded without the aid of external heat, the gas being almost completely utilized, was stopped when the required gain in weight had been attained. Chlorination was not uniform, mono- and di-chloro derivatives being formed before all the paraffin was attacked. Olefines were produced by heating the chloro-paraffins with alcoholic potash. On treatment with potassium permanganate, an olefine of bromine value 20·4 obtained from a chloro-paraffin containing 10·6% Cl. gave an acid $C_{14}H_{29}COOH$, which was isolated as silver salt. The less saturated olefines were oxidized more rapidly and to a greater extent. Modifications in procedure were adopted since it was found the oxidizability of the olefines depended on their state of division. An olefine, derived from a chloro-paraffin containing 32% Cl., was emulsified in an aqueous solution of sodium palmitate and treated with aqueous potassium permanganate. The reaction was rapid and practically complete when the olefine had reduced six times its weight of permanganate. When the reaction was started with small quantities of sodium palmitate and olefine and the latter added as the potassium permanganate was reduced, a product of higher acid value was obtained, the amount of crude acid and the relative proportions of fatty acids and unsaponifiable matter being the same. Oxidation of olefines containing a considerable number of double bonds yields considerable quantities of acids soluble in water and much carbon-dioxide.

Ozone is readily absorbed at 40° C. by the olefines in the absence of solvent, in quantity corresponding with the hydrogen-chloride eliminated in the formation of the olefine. On treatment with water the ozonides are broken down, and the non-acidic aldehydic portion may be oxidized with ozone. Higher fatty acids (105 g.) and considerable quantities of water-soluble lower acids were obtained from 150 g. of olefine derived from a chloro-paraffin containing 19·4% Cl.

Paraffin Wax. Oxidation of—to a true wax in ultra-violet light.—A. Grün & T. Wirth. *Z. angew. Chem.* 1920, **33**, 291–2. U.S. Pat. 1,158,205. *J. Soc. Chem. Ind.*, 1915, 1200.

Oxidation of paraffin wax at 160° C. in a current of air was shown to be practically unaffected by ultra-violet light.

ALIPHATIC HYDROCARBONS. Oxidation of—by nitrogen peroxide.—C. Grânacher. *Helv. Chim. Acta*, 1920–3, 721–37.

Paraffin wax m.p. 50–2° C. is oxidized by air containing 2% nitrogen peroxide to mixtures of acetic, butyric, and higher fatty acids with 15% unsaponifiable oil. The reaction proceeds at 110–50° C., requiring periods from ten to twenty-four days, according to temperature. With pure nitrogen peroxide oxidation is complete in eight to ten hours at 140° C., nitric-oxide being evolved. Nitrogen, hydrogen cyanide, and nitro bodies are apparently also formed under these conditions, and the solution of the oxidized wax in caustic soda is red. Pure n-undecane treated with nitrogen peroxide at 140° C. gave nonoic acid and lower fatty acids, 40% being unacted upon. This method will therefore not give any definite acid from a particular hydrocarbon, and the natural higher paraffins probably only contain small quantities of normal members.

GAS. Removal of sulphur (hydrogen sulphide) from.—N. E. Rambush. E.P. 153,665. 11/8/19.

The gas is washed with a suspension of ferric-hydroxide in ferrous sulphate solution.

CHLORHYDRIN AND BROMHYDRIN. Process and apparatus for manufacture of. E.P. 126,311, 2/5/19. *J. Soc. Chem. Ind.*, 1920, 764A).

Olefinic gases are absorbed in solution of hypochlorous or hypobromous acids. The absorbing solutions are made in the upper part of a vessel by action of chlorine or bromine on a solution such as a borate, which is capable of removing free halogen acid. Absorption of the gases takes place in the bottom of the vessel or tower. The solution is drawn off and cooled to remove boric acid. It is recirculated after saturation with borax. The process is repeated until sufficient halogen-hydrin has been produced in the solution. The halogen-hydrin is then isolated by solution or extraction with a solvent.

ETHYLENE AND PROPYLENE. Absorption of—by sulphuric acid.—Plant & Sidgwick. *J. Soc. Chem. Ind.*, 1921, **40**, 14–18.

The effect of varying conditions on the rate of absorption of ethylene in sulphuric acid have been studied, and also the products and mechanism of the reaction. It is shown that with the apparatus used the velocity of the ethylene-air mixture above certain minimum speeds has little effect on the rate of absorption. Above 69% the rate of absorption is also not affected by the percentage of ethylene in the mixture. Curves are given connecting the gain in weight of varying strengths of sulphuric acid and oleum with the time of absorption, temperatures of 50° C., 70° C., 100° C., and 125° C. being investigated.

The mechanism of the reaction is shown to consist of three stages: (1) Solution of ethylene in the liquid; (2) formation of ethyl sulphuric acid; (3) formation of diethyl sulphate. The fact that it is not necessary for all the sulphuric acid to be converted into ethyl sulphuric acid before

the formation of diethyl sulphate proceeds is shown by the analyses. Reaction (2) and (3) proceed at rates proportional to the products of the concentration of ethylene and the concentrations of sulphuric acid and ethyl sulphuric acid respectively. The curves indicate that ethyl sulphuric acid has an autocatalytic effect, explained by the greater solubility of ethylene as ethyl sulphuric acid accumulates. Diethyl sulphate begins to appear after about 20% absorption. The amount of diethyl sulphate present at any degree of absorption is practically independent of the strength of acid used.

Propylene is more readily absorbed by sulphuric acid than ethylene, but the reactions are more complex. In addition to propyl sulphuric acid and dipropyl sulphate, a colourless oil is formed which appears to be a mixture of open-chain secondary alcohols. The propylene is apparently polymerized to a higher olefine of the formula $CH_2(CH_2)nCH{:}CH_2$, which gives a secondary alcohol. Physical constants indicate that the molecule is of the order of C_{12}.

CHOLESTEROL. Contact decomposition of—Theory of petroleum formation. —W. Steinkoff, H. Winternity, W. Roederer & A. W. Wolynski. *J. Prakr. Chem.*, 1919, **100**, 65–85.

With the exception that some fractions of petroleum are lævo-rotatory, the view that the optical activity of petroleum originates from cholesterol and its derivates accounts for most of the facts. It is shown that when cholesterol is heated above 130°–200° C., or in the presence of kieselguhr at 150° C., the lævo-rotation diminishes to a minimum and then increases. Under natural conditions, cholesterol possibly forms first a lævo, and then a dextro-rotatory cholesterylene, which give products some richer, some poorer, in hydrogen."

PETROLEUM. Specific heat of—at different temperatures.—F. W. Bushong & L. L. Knight. *J. Ind. Eng. Chem.*, 1920, **12**, 1198–1200.

The specific heats of petroleum products at different temperatures are given in tabular and graphic form. The value increases with increase of temperature. For solid paraffin the value is 0·12 at 210° C. and 0·47 at 0° C.; for liquid paraffin, 0·57 at 52° C. and 0·6307 at 100° C.; for petroleum distillates, 0·4703 at 21·1° C. and 0·5720 at 68° C.

GASOLINE. Absorption as applied to recovery of.—W. P. Dykema & P. O. Neal. *U.S. Bur. of Mines Tech. Paper* 232, 1920. 40 pp.

The absorption method of recovering gasoline is more efficient than compression and is applicable either to rich gas (2–6 gal. gasoline per 100 cub. ft.) or to residual lean gases from compression plant. Using naphtha as absorbent, a plant to handle 500,000 cub. ft. can be installed for less than $1000. Details are given of satisfactory units, rates of flow, etc., and the recovery of gasoline from the absorbent by distillation. Portable testing apparatus for determining the gasoline content of natural gas is also described.

PETROLEUM. New method of fractional distillation of.—H. Offerman. *Chem. Zeit.*, 1920, **44**, 773–4.

Wet steam at 100° C. is used in distilling the heavy fractions of oil instead of the usual method of superheated steam, and higher yields of more viscous oils with smaller amounts of pitch are claimed. The explanations suggested are that cool steam (plus entrained water) represents a greater amount of water per unit volume; and that the evaporation of the entrained droplets within the oil increases the efficiency of contact of steam with oil.

REPORT OF LUBRICANTS AND LUBRICATION ENQUIRY COMMITTEE (Dept. of Sci. and Ind. Research), 1920. 80–4. **A. B. C.**

A.—VISCOSITIES OF LIQUIDS AT HIGH PRESSURES. Apparatus for determination of absolute—and results obtained for certain lubricating oils.—J. H. Hyde.

An apparatus for determining absolute viscosities under high pressures is described, illustrations of the arrangement of the heating walls, etc., being given. All the oils tested showed rapid rise in viscosity with pressure.

	Pressure tons per sq. in.	Value in cgs. units.	Temp. °C.
Castor Oil	1·44	227·5	40·2
,, ...	5·49	864·5	40·0
,, ...	7·39	1164·0	40·5
,, ...	atmospheric	1·94	—
Mobiloil B.B./mineral .	1·49	227·5	40
,, ...	4·51	710·0	39·8
,, ...	6·47	1019·0	40
,, ...	atmospheric	1·58	40
Bayonne (mineral) .	1	157·5	39·9
,, .	4	630·0	40
,, .	8	1260·0	40
,, .	atmospheric	0·49	40

B.—LUBRICATING OIL. Compressibility of—under high pressures, and the application of the results to the tests in the high-pressure viscosimeter to obtain the value of the viscosities of the oil.—J. H. Hyde.

The densities of oils under pressures were determined by compressing them in a steel cylinder. The densities at 40° C. under pressure are given in the following table:—

Pressure. Tons per sq. in.	Castor Oil.	Sperm Oil.	Cyl. Oil.	Mobiloil B.B.
0	0·9415	0·866	0·877	0·899
4	0·9865	0·896	0·904	0·920
8	0·9905	0·9195	0·926	0·949
10	1·001	—	—	—

C.—Viscosities of Liquids at High Pressure. Absolute. Results of tests on rape, sperm, and FFF cylinder oils.—J. H. Hyde.

The behaviour of rape and sperm oils is similar to that of castor oil and the mineral oil resembled mobiloil and Bayonne lubricating oil.

Gas. Purification of—from sulphur compounds.—H. L. Doherty. U.S. Pat. 1,360,734.

The gas is scrubbed with ammonia solution under pressure, the ammonia being recovered.

Hydrocarbon Oil. Treatment of.—N. V. S. Knibbs. E.P. 154,464.

Products of lower boiling-point are obtained by heating hydrocarbon oils with alkali metals, e.g. sodium, or an alloy of the same. The treatment is carried out either in a still or by passing the oil vapour through the molten metal.

Hydrocarbon Oil. Apparatus for treating.—M. J. Trumble, U.S. Pat. 1,349,799

Oil is sprayed into a separator through which hot furnace gases are passing in the same direction.

Petroleum Oils. Process of desulphurizing.—E. B. Cobb. U.S. Pats. (A) 1,357,224 and (B) 1,357,225, 20/11/20.

Elementary sulphur is removed by treatment with (A) an alkaline hydroxide and hydrogen sulphide, or (B) an alkaline earth sulphide.

Aromatic Hydrocarbons. The determination of—in mixtures of hydrocarbons.—H. T. Tizard & A. G. Marshall. *J. Soc. Chem. Ind.*, 1921, **40**, T20–25.

The determination of the critical solution temperature of hydrocarbons in aniline is preferred to sulphonation as a method of determining the percentage of aromatic hydrocarbon present. The procedure and apparatus necessary are described. A mixture of 10 cc. aniline and 10 cc. hydrocarbon is cooled slowly until it becomes turbid, the temperature at which this occurs being called the aniline point. Several determinations are necessary to eliminate error due to lag of the thermometer. A determination is first made with a petrol from which the aromatic hydrocarbons have been removed by shaking with 98% H_2SO_4, and then with the mixture containing the aromatic hydrocarbons. The difference gives the lowering of the aniline point and is very nearly proportional to amount of aromatic hydrocarbon present. The following table gives the relationship between the lowering of the aniline point for various percentages of aromatic hydrocarbon :—

Percentage of hydrocarbon.			Lowering of aniline point.
5%	by weight	..	4·2
10%	,,	..	8·6
15%	,,	..	13·2
20%	,,	..	18·1
25%	,,	..	23·2
30%	,,	..	28·5
35%	,,	..	34·0
40%	,,	..	39·8

The aniline point is not the true critical temperature above which aniline and the hydrocarbon are miscible in all proportions, but approximates very closely to it when the percentage of aromatic hydrocarbons is low. Curves and examples given show that the method is very accurate. The method of selecting 'cutting points' in distillations of mixtures of non-aromatic hydrocarbons with benzene, toluene, and xylene is described. The method is only applicable to mixtures which contain negligible quantities of unsaturated compounds.

ETHYLENE. Extraction of—from gaseous mixtures (and its recovery as alcohol).—W. Traube. E.P. 147,543.

Chlorsulphonic acid is used as a reagent for removing ethylene from gases containing the same, e.g. dry coke-oven gas. The gas is sprayed with 90–100% chlorsulphonic acid with cooling. A liquid containing 90–100% of the ethyl ester of chlorsulphonic acid is obtained and is decomposed into alcohol, hydrochloric and sulphuric acids with an equal volume of water.

PARAFFIN WAX. Treatment of—for the production of oxygenated compounds.—A. Schmidt. E.P. 142,507.

Fatty acids and small quantities of aldehydes and alcohols are obtained by passing air through paraffin wax at 100–120° C. till the colour becomes deep yellow. The oxidation takes fifty hours and is hastened by the addition of catalysts, e.g. mercuric oxide or previously treated wax.

LUBRICATING OIL. Production of, from lignite producer-gas tar oil.—G.P. 310,075.

The tar is distilled. The distillate is freed from paraffin and heated under pressure to 250–400° C. The product is again distilled, the low-boiling products being suitable for Diesel engines.

AIR FACTOR. Calculation of the (during combustion).—A. B. Helbig. *Feurungstech.*, 1921, **9**, 53–8.

The air requirements of liquid and gaseous fuels may be calculated from the analysis of the flue gases by the aid of a triangular diagram. The method is worked out.

PETROL. Blended—containing casinghead gasoline.—F. Bordas. *Ann. Falsif.*, 1920, **13**, 539–43.

Modifications of current tests are described to distinguish between blended gasoline and straight-run petrol, owing to the increased fire risk and heavy residue of the former.

MINERAL OILS. Estimation of pitchy substances (asphalt and resin) in.—G. Armani & A. G. Rodano. *Giorn. Chim. Ind. Applic.*, 1920, **1**, 45–8.

The following method of determining asphaltic and pitchy substances in mineral oil is given. A weighed quantity (about 10 cc.) of the oil is dissolved in 100 cc. of light petroleum, which should not be attacked by concentrated sulphuric acid and of which the sp. gr. is not higher than 0·700. Concentrated sulphuric acid (5 cc.) of sp. gr. 1·84 is added and the mixture shaken. It is allowed to stand for twelve hours. Fifty cc. of the petroleum are removed, washed with water, and evaporated in a tarred flask. The residual oil is half of the pure mineral oil in the sample originally taken. Saponifiable matters in mineral oils containing fats or blown vegetable oils must first be removed.

GASOLINE BY THE CHARCOAL ABSORPTION PROCESS.—G. A. Burrell, G. G. Oberfell & C. L. Voress. *Chem. Met. Eng.*, 1921, **24**, 156–60.

A method is described in which gasoline is removed from natural gas by absorption in activated charcoal. When absorption is complete the stream of gas is replaced by superheated steam which expels the absorbed liquid constituents. Cocoanut shell charcoal in granules from 8–14 mesh and which has been activated by the steam activation process is best. The charcoal exhibits selective absorption, ethane, propane, and butane being absorbed first and then replaced by heavier fractions. This fact makes it possible to vary the quality of the product by regulating the extent of the absorption. On first coming in contact with the charcoal the gas causes a rise in temperature owing to the liberation of the latent heat of the condensed vapours, but after a few minutes the rise ceases, the heat being used to vaporize lighter fractions previously condensed. A gas rich in gasoline may cause a rise in temperature to 60° C. The efficiency of the absorption is influenced by the temperature of the inflowing gas. At 10° C. there is 100% absorption, but the efficiency falls constantly with rise of temperature until at 300° C. there is no absorption at all. The rate depends on the richness of the gas. A gas giving 400 gallons of gasoline per 1,000,000 cub. ft. may be passed at the rate of 40 cub. ft. per hour per sq. in. of base surface in a 5 ft. column of charcoal. After absorption is complete it is necessary to heat to 200° C. to expel the heavy fractions, and the steam employed is heated to 250° C. or higher. The vapour is preferably passed through two condensers in series, the first condensing the major portion of the steam just below 100° C.; in the second cooling water at 15° C. is used to complete

condensation. An oil plant and a charcoal plant working on the same gas on the same day gave 125 and 203 gallons of gasoline per 1,000,000 cub. ft. respectively.

ALCOHOL. Manufacture of—from coke-oven gas.—Tidman. *Journ. Soc. Chem. Ind.*, **40**, 86T.

In experimental work carried out at Skinningrove on the absorption of ethylene in coke-oven gas by sulphuric acid optimum conditions for carrying out the absorption were determined. The best temperature was found to be about 60–80° C. Under laboratory conditions 95% H_2SO_4 will absorb 90% of the ethylene present if the gas and acid are in contact for three minutes. The presence of silica favours the absorption, but its function is not clear. The absorption of 80–90% was not realized on a larger scale. With mechanically agitated washers absorption goes on after the acid has fallen to 77% H_2SO_4. The absorption product contains free alcohol in addition to ethylhydrogen sulphate, diethyl sulphate, and sulphuric acid. The recovery of the alcohol was carried out by diluting the acid to 64% H_2SO_4 with water and distilled under diminished pressure, steam being admitted when the rate of distillation fell off. Under a vacuum of 26½ inches distillation commenced at 94° C. and finished at 146° C. The recovered sulphuric acid, which was free from alcohol, contained 80% H_2SO_4. The alcohol was obtained in the form of a 15% distillate and is impure, containing, amongst other substances, diethyl disulphide.

FATTY ACIDS. Production of alkali salts of—(from petroleum hydrocarbons etc.)—W. Schrauth. G.P. 327,048.

Chlorinated petroleum fractions, preferably mono-chloro derivatives, are fused at 200–300° C. with alkali in such a manner as to avoid high pressure. The temperature is first maintained at 200–230° C., and later raised to 300° C. In six to eight hours the products contain dry, odourless soaps, soluble in hot water and giving an abundant lather. The excess of alkali may be neutralized with hydrochloric acid or fatty acids, or extracted after remelting. The hydrogen evolved during the fusion may be utilized technically. From cetyl chloride palmitic acid is obtained.

PETROLEUM. Formation of—from fish oils. Origin of Japanese petroleum.—K. Kobayashi. *Kôgyô-Kwagaku Zasshi* (*J. Chem. Ind. Japan*), 1921, **24**, 1–26.

A mixture of herring oil (4000 cc. sp. gr. 0·9214, saponif. value 187·7) and finely powdered Japanese acid clay (4000 gr.), covered with the same clay (4000 gr.), was distilled in an iron retort at ordinary pressure. A crude oil (2000 cc.) and water (1800 cc.) were obtained along with acrolein, carbon dioxide, soluble fatty acids such as acetic acid, other fatty acids, naphthenic acids, and hydrocarbons. The oil distillate (sp. gr. ·8160 at 15° C., saponif. value 15·1, percentage absorbed by concentrated sulphuric acid 14·5) had a greenish fluorescence and a

petroleum-like odour, and closely resembled natural crude petroleum. The hydrocarbons in the oil were mainly of the naphthene series, together with a considerable quantity of olefines. The formation of the hydrocarbons is attributed to the action of the Japanese acid clay Al_2O_3, $6SiO_2$, xH_2O. The fish oil is hydrolyzed to fatty acids and glycerol by the action of the water in the clay; and the fatty acids are decomposed into hydrocarbons, by the elimination of carbon dioxide and with the formation of acetic and naphthenic acids. The hydrocarbons thus formed are cracked to lighter ones by the upper layer of clay. The oil-fields of Japan are associated with the outcrops of Japanese acid clay, and Japanese petroleum is accompanied by salt water. It is suggested that natural processes similar to that given above account for the formation of Japanese petroleum from marine animals.

"Oilcoals" (deposits in internal combustion engines, etc.). Composition and formation of.—J. Marcusson. *Brennstoff. Chem.*, 1921, **2**, 103–4.

The carbonaceous deposits formed in internal combustion engines, compressors, steam-engines, etc., are termed by the author "oilcoals." The deposits generally consist of an oily portion soluble in benzine, a brittle asphaltic constituent insoluble in benzine, a coaly portion, and mineral ash. The author finds that the coaly portion, previously considered insoluble in organic solvents, is soluble in large excess of solvent. From the solution, products of oxidation of mineral oils ('carbenes' or 'carboids') and asphaltogenic acids or their anhydrides were separated. The deposit from a hydrogen compressor consisted of oil soluble in benzine 6%, black solid material (half saponifiable), soluble in chloroform 8%, and 86% of material insoluble in chloroform. The theory advanced is that, by previous long use of the oil, resinification and the formation of asphaltenes, carbenes and asphaltic acids has taken place.

Coal Gas and Coke-oven Gas. Determination of benzene hydrocarbons in.—E. Berl, K. Andress & W. Müller. *Z. angew. Chem.*, 1921, **34**, 125–7.

The hydrocarbons are absorbed in charcoal and afterwards removed by steam to a measuring burette. The apparatus consists of a U-tube containing charcoal, through which the gas is passed at a rate depending on the content of benzene hydrocarbons, but is approximately 250 litres per hour. When absorption is complete, the U-tube is connected at one end to a steam supply and at the other to a condenser and the measuring burette. Steam is passed for half an hour, the tube being heated in a bath to 110–120° C. More accurate results are obtained than by freezing, paraffin oil, and dinitrobenzene methods, and is applicable when only small quantities of benzene hydrocarbons are present.

Paraffin Wax. Pressure oxidation of.—F. Fischer. *Ges. Abhandl. Kennt. Kohle*, 1919, **4**, 35–47. *Chem. Zentr.*, 1921, **92**, II, 377.

Hard paraffin wax (200 gr.) was placed in a horizontal autoclave fitted with an agitator along with 800 ccm. 2·5 N. Na_2CO_3 solution.

Air at 30 atmospheric pressure was passed through the apparatus at the rate of 200 litres per hour, and the oxidation carried out at 170° C. When one-half of the sodium carbonate solution was neutralized by the fatty acids formed the oxidation was stopped. Fatty acids, of average molecular weight 250, suitable for soap manufacture were obtained. The residue was not pure paraffin wax, and other acids soluble in water were also produced, along with considerable quantities of carbon dioxide. Some light paraffin oils were obtained. Some decomposition of the sodium salts of the higher fatty acids occurs during the reaction.

Pressure Oxidation of Paraffin Wax. Influence of various factors during the.—F. Fischer & W. Schneider. *Ges. Abhandl. Kennt. Kohle*, 1919, **4**, 48–93. *Chem. Zentr.*, 1921, **92**, II, 377–8.

The degree of filling of the autoclave in the pressure oxidation of paraffin wax was found to be important. Rise in temperature affected the colour of the products, as well as the speed of oxidation. The molecular weight of the acids obtained was affected by the quantity of air. The reaction was accelerated by increase of air pressure. Secondary decomposition of the acids produced was caused by unduly prolonging the oxidation. Agitation, quantity and concentration of alkali were found to have little influence on the reaction. Lime was not satisfactory as a base. Various catalysts were tried; ceria, titania, fuller's earth, and charcoal gave products of the best colour, but iron and manganese were the best catalysts. Addition of toluene and xylene improved the yield of fatty acids, although these substances are not oxidized under the conditions of experiment in the absence of paraffins Glass or lead lining to the apparatus retarded the reaction, but better coloured products were obtained. Paraffins obtained from lignite, coal, peat, or mineral oil are all suitable for pressure oxidation. In the absence of alkalis, paraffin wax was oxidized more extensively than in their presence, 74% of the consumed paraffin being recovered as fatty acids, but their colour was dark brown.

Air-Benzine Mixture. Determination of higher and lower limits of explosion of.—W. Reinders. *Chem. Weekblad.*, 1921, **18**, 157–9.

The higher and lower limits of explosibility of air saturated with benzine vapour at various temperatures are determined, the results with many benzine fractions being tabulated. With the light benzine fractions used in motor-cars air saturated above 0° C. is not explosible; the heavy fractions 6.p. 100–200° C. sp. gr. ·740–750 constitute a risk, and the vapours should be displaced from storage reservoirs by inert gases such as nitrogen and carbon dioxide.

Colorado Shale Oils. Investigation of.—A. J. Franks. *Chem. and Met. Eng.*, 1921, **24**, 561–4.

Shale oils from the low-temperature carbonization of shales from

various strata were distilled and each 10% (by vol.) of the distillate examined separately. Curves plotted to show the relation between temperature and percentage distilled show the similarity in the character of the oils, a sharp bend at 350–360° C. showing the temperatures between which cracking occurs, although this takes place slightly even at 300° C. Curves obtained with composite samples from the secondary and primary condensers show that the oil vapours cannot be fractionally condensed with success. Saturation decreases with increase of boiling-point and specific gravity up to the point where cracking begins. The cracking of the unsaturated oils in the heavy fractions produces oils of higher saturation.

SHALE AND THE LIKE MATERIAL. Method and apparatus for treating.—L. B. Ard. U.S. Pat. 1,373,698–9.

The shale is passed slowly through molten metal, whilst the whole of the volatile matter is removed.

HYDROCARBONS. Production of light.—*Allgem. Ges. für Chem. Ind.*, m.b.h. G.P. 333,168, 5/12/17.

The oils obtained by distilling petroleum or lignite tar are purified by treatment with liquid sulphur dioxide and are then distilled with aluminium chloride, yielding 70% or more of light petroleum spirit.

PETROLEUM OILS. Recovery of—from the acid resin obtained in refining petroleum. G.P. 333,109.

After the removal of free acid the resin is dried and then agitated at 120–125° C. with concentrated sulphuric acid. The distilled product yields an oil of moderately high boiling-point which can be used for heating or lighting, or as a lubricant. The residual resin, which is of higher melting-point than the original, can be used as an insulator.

LIQUID FUEL FOR STEAM RAISING.—N. A. Anfilogoff. *J. Soc. Chem. Ind.* **40**, R.205–9.

The author states that in all industries where heat is required oil can successfully replace coal, and for steam raising is much more efficient. In the Lancashire boiler more heating surface is obtained with oil fuel than with coal, and the more easily controlled flame gives a better head of steam. Fewer boilers and less labour are required with oil firing. Theoretically with coal of 14,000 B.Th.U. and oil of 19,000 B.Th.U. 1 lb. of oil is equivalent to 1·4 lb. of coal. In practice, taking monthly consumption figures, the writer has rarely exceeded an evaporation of 8 lb. of water per lb. of coal, and invariably obtained an evaporation of 15·6 lb. of water per lb. of oil. These actual consumption figures show 1 lb. of oil to be equal to 1·95 lb. of coal. With coal at 50/– per ton and oil at 90/– per ton, the following costs are given for a four-boiler plant evaporating 72,000 gals. of water daily :—

Evaporation cost. Coal.				Evaporation cost. Oil.			
72,000 gal., or 321½ tons, at 6/3 .	£100	9	4	321½ tons at 5/9 . .	£92	8	7
1 Fireman at 2/– .	2	8	0	1 Fireman . . .	2	8	0
1 Assistant ,, 1/11 .	2	6	0				
1 Trimmer ,, 1/10 .	2	4	0				
	£107	7	4		£94	16	7

The life of a boiler under oil firing should be longer than under coal firing, owing to the more regular heating and the fact that the fire-doors have not to be opened for stoking, thus admitting cold gusts of air.

For successful oil-firing it is essential to provide (1) a means of converting the oil into vapour, and (2) sufficient air to support combustion.

The author prefers burners of the "inside mixer" type, which consume 1·9 to 3 per cent of the steam raised, to "outside mixer" type, which consume 5 to 8 per cent of the raised steam. The flame should be comparatively silent and should be not quite smokeless. A ready method of calculating the air requirements of the fuel is to divide the calorific value of the fuel in B.Th.U. by 110. Thus a fuel of 19,000 B.Th.U. would require 100 cub. ft. of air per lb.

The method of delivery of the oil to the burner and a simple preheater are described. The precautions to be observed in the boiler-house are given.

Contact Ring Still Heads. Fractional distillation with.—R. Lessing. *J. Soc. Chem. Ind.* **40**, T.115–8.

The efficiency of contact rings (E.P. 139,800) devised by the writer is demonstrated by distillation curves of benzene-toluene and other mixtures. The rings, which are of the Raschig type, but are split down one side and divided by a partition, are made by bending one strip of metal.

Refractive Index of Roumanian Petroleum.—C. Predescu. *Bul. Sci. Acad. Roumaine*, 1920, **6**, 150–6.

The refractive index of Roumanian petroleum varies directly with the boiling-point of the fractions. The fraction b.p. 50°–100° C. has $n_D^{15}=1{\cdot}384$ and sp. gr. ·683; the fraction b.p. 340°–350° C. has $n_D^{15}=1{\cdot}526$ and sp. gr. ·9051. Optically active substances occur in the higher boiling fractions of Roumanian petroleums. After dilution and filtration through fuller's earth two oils had $[\alpha]_D^{20}=+1{\cdot}19$ and $+1{\cdot}52$ respectively.

Petroleum. Capillary constants of Roumanian.—C. Predescu. *Bull. Sci. Acad. Roumaine*, 1920, **6**, 188–96.

The capillary constant (a) is determined by the capillary tube method and is found to increase with the b.p. of the fraction. For the

fraction b.p. 50°–60° C., $\alpha = 1{\cdot}92$, and for the fraction b.p. 340°–350° C., $\alpha = 3{\cdot}18$. The viscosity of the fractions increases more rapidly than does the capillary constant.

LIGHT PETROLEUM (pentane, hexane, heptane, octane). Narcotic action of.—H. Fühner, *Biochem. Zeitsch*, 1921, **115**, 235–61.

The hydrocarbons mentioned, when inhaled by rats and mice, often cause great excitement and soon adversely affect the respiration. Benzene is a more powerful excitant. Hexane has about the same activity as an anæsthetic as ether, heptane as benzene, and octane as chloroform.

CONSTITUENTS OF THE DISTILLATION GAS FROM FUEL [e.g. Ethylene]. Process for the separate recovery of.—F. Bergius & P. Kalnin. E.P. 146,332.

After being freed from tar, ammonia, and benzene the gas is passed over absorbent charcoal at 0°–20° C. The gas is expelled and the treatment repeated. By repeated adsorption the ethylene content can be increased from 1–2% to 17, 36, and 59%.

PETROLEUM OILS. Apparatus for distilling.—A. D. Smith. U.S. Pat. 1,374,402.

Circulation of oil is induced by heating sloping tubes connected at one end with a well and at the other with the sloping bottom of a still which is also connected with the well. The circulation diminishes the deposition of carbon in the apparatus.

CORROSION PREVENTION IN PETROLEUM REFINING VAPOUR SYSTEMS.—R. R. Mathews & P. A. Crosby. *Chem. Met. Eng.*, 1920, **23**, 1122–3

The HCl formed during the distillation of crude oil is neutralized by the addition of anhydrous ammonia to the vapour line between the stills and dephlegmators. The ammonia is controlled by a regulating valve, the quantity admitted being such that the water in the receiving house has the odour of ammonia or is slightly alkaline. When ammonia was used a tubular condenser operated 280 days without any replacements against 100 days when ammonia was not used.

ASPHALT AND COKE CONTENT OF PETROLEUM. The relations between.—Wilhelm Steinkopf & Hans Winternitz. *J. Prakt. Chem.*, 1920, **101**, 82–92.

The content of hard and soft asphalt, and also the coke formed both in vacuo and at ordinary pressure, were determined in seventeen different oils. It was found that 40% of the hard asphalt and 40–60% of the soft asphalt were converted into coke. Distillation in vacuo yielded less coke than distillation at ordinary pressure, especially in the case of oils rich in asphalt.

KETONES FROM CRACKED GASOLINE.—W. J. Hund. U.S. Pat. 1,365,053.

Cracked gasoline containing olefines is treated with H_2SO_4 of 1·8 sp. gr. The resulting acid sulphate is isolated and oxidized electro-

lytically to produce a ketonic material suitable for use as a solvent for cellulose acetate.

Converting Mineral Oils into Higher Boiling Products.—W. North. G.P. 319,123.

The oils are heated with carbon under high hydraulic pressure to high temperatures. A paraffin oil in which solid paraffin cannot be detected is heated for one hour with gas-coke under a pressure of 400 atmos. at 300° C. The yield of soft wax m.p. 38·5° C. is 20%.

The above abstracts cover the literature for the first half of 1921. Subsequent numbers of the Journal will contain current abstracts within the periods of publication. The Abstractor desires to express his indebtedness to the Abstract Sections of the Society of Chemical Industry, and of the American Chemical Society.

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